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MAY 78 J R HUGHES, W E AMES, D A MISITANO WESRF-7T-22

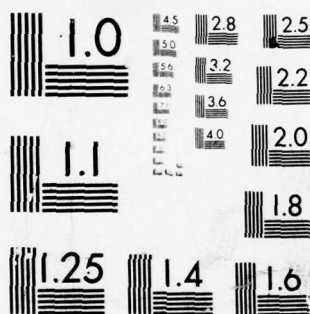
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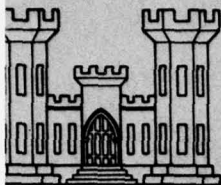


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# DREDGED MATERIAL RESEARCH PROGRAM



TECHNICAL REPORT D-77-24

## AQUATIC DISPOSAL FIELD INVESTIGATIONS DUWAMISH WATERWAY DISPOSAL SITE PUGET SOUND, WASHINGTON

### APPENDIX A: EFFECTS OF DREDGED MATERIAL DISPOSAL ON DEMERSAL FISH AND SHELLFISH IN ELLIOTT BAY SEATTLE, WASHINGTON

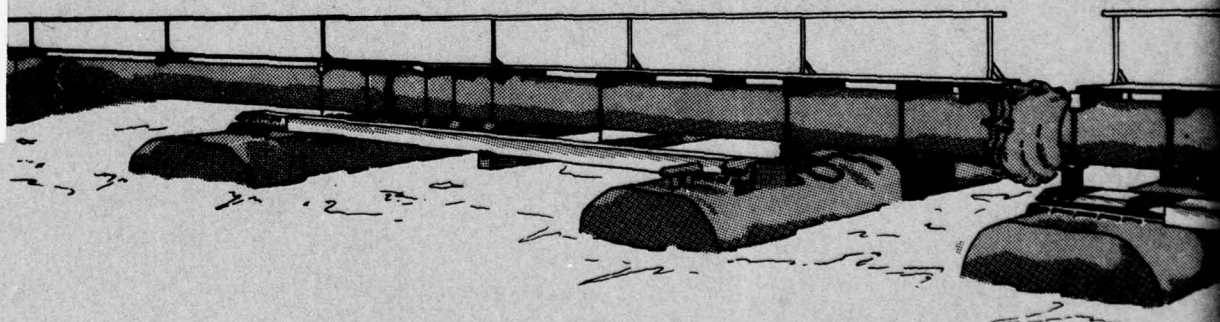
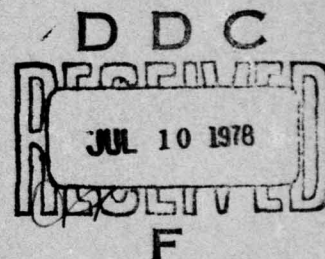
by

John R. Hughes, Warren E. Ames  
David A. Misitano, George F. Slusser

National Marine Fisheries Service  
Northwest and Alaska Fisheries Center  
Mukilteo, Wash. 98275

May 1978  
Final Report

Approved For Public Release; Distribution Unlimited



Prepared for Office, Chief of Engineers, U. S. Army  
Washington, D. C. 20314

Under Interagency Agreement No. WESRF 7T-22  
(DMRP Work Unit No. 1A10B)

Monitored by Environmental Laboratory  
U. S. Army Engineer Waterways Experiment Station  
P. O. Box 631, Vicksburg, Miss. 39180

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**AQUATIC DISPOSAL FIELD INVESTIGATIONS  
DUWAMISH WATERWAY DISPOSAL SITE  
PUGET SOUND, WASHINGTON**

- Appendix A: Effects of Dredged Material Disposal on Demersal Fish and Shellfish in Elliott Bay, Seattle, Washington**
- Appendix B: Role of Disposal of PCB-Contaminated Sediment in the Accumulation of PCB's by Marine Animals**
- Appendix C: Effects of Dredged Material Disposal on the Concentration of Mercury and Chromium in Several Species of Marine Animals**
- Appendix D: Chemical and Physical Analyses of Water and Sediment in Relation to Disposal of Dredged Material in Elliott Bay**
- Appendix E: Release and Distribution of Polychlorinated Biphenyls Induced by Open-Water Dredge Disposal Activities**
- Appendix F: Recolonization of Benthic Macrofauna over a Deep-Water Disposal Site**
- Appendix G: Benthic Community Structural Changes Resulting from Dredged Material Disposal, Elliott Bay Disposal Site**

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DEPARTMENT OF THE ARMY  
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IN REPLY REFER TO: WESYV

15 June 1978

SUBJECT: Transmittal of Technical Report D-77-24 (Appendix A)

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of one of several research efforts (Work Units) undertaken as part of Task 1A, Aquatic Disposal Field Investigations, of the Corps of Engineers' Dredged Material Research Program. Task 1A was a part of the Environmental Impacts and Criteria Development Project (EICDP), which had as a general objective determination of the magnitude and extent of effects of disposal sites on organisms and the quality of surrounding water, and the rate, diversity, and extent such sites are recolonized by benthic flora and fauna. The study reported on herein was an integral part of a series of research contracts jointly developed to achieve the EICDP general objective at the Duwamish Waterway Disposal Site, one of five sites located in several geographical regions of the United States. Consequently, this report presents results and interpretations of but one of several closely interrelated efforts and should be used only in conjunction with and consideration of the other related reports for this site.

2. This report, Appendix A: Effects of Dredged Material Disposal on Demersal Fish and Shellfish in Elliott Bay, Seattle, Washington, is one of seven contractor-prepared appendices published relative to Waterways Experiment Station Technical Report D-77-24 entitled: Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington. The titles of all contractor-prepared appendices of this series are listed on the inside front cover of this report. The main report will provide additional results, interpretations, and conclusions not found in the individual appendices and will provide a comprehensive summary and synthesis overview of the entire project.

3. The purpose of this study, conducted as part of Work Unit 1A10B, was to determine the effects of open-water disposal of contaminated dredged material from the Duwamish River on the indigenous demersal fish and shellfish at the Elliott Bay disposal site. A Marinovich try net was used to sample the disposal site and the two reference sites prior to the disposal of the dredged material, during disposal, and 1 week and 1, 3, 6, and 9 months after disposal. Statistical analyses revealed significant differences between the three sampling sites; however, it was concluded by the authors that these differences were probably due to natural population fluctuations caused by seasonal migrations.

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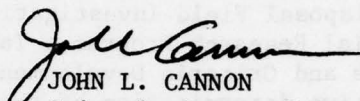
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4. It was concluded that the volume of dredged material released at the disposal site did not have a lasting effect on the composition and abundance of the demersal fish and shellfish at the Elliott Bay disposal site.

5. The results of this study are important in determining placement of dredged material for open-water disposal. Referenced studies, as well as the ones summarized in this report, will aid in determining the optimum disposal conditions and site selection for either the dispersion of the material from the dump site or for its retention within the confines of the site, whichever is preferred for maximum environmental protection at a given site.

  
JOHN L. CANNON  
Colonel, Corps of Engineers  
Commander and Director

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20. ABSTRACT (Continued).

the effects of dredged material disposal on demersal fish and shellfish at the disposal site. A standard Marinovich "try net" was used to sample the disposal site and two reference sites. Catches of both fish and shellfish were inconsistent at the three sites with respect to both numbers and species, indicating a seasonal fluctuation in both abundance and composition. Statistical analyses showed that differences in abundance and composition were significant among the different sampling sites and the different sampling periods. However, experimental design and inherent differences among the sampling sites made it difficult to determine whether the catch differences were attributable to effects of the dredged material disposal or simply manifestations of population fluctuations due to migratory behavior patterns. It was concluded that the quantity of dredged material dumped during the study did not have a lasting detrimental effect on the demersal fish and shellfish populations at the disposal site. The investigators recommend (a) that any future study include a longer period of time for collecting baseline data, (b) that the characteristics of the reference sites be more comparable to those of the disposal site, and (c) that the disposal operations be conducted in a manner similar to that which is used in actual practice so the results might have general application.

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## SUMMARY

The National Marine Fisheries Service, sponsored by the Office, Chief of Engineers, participated in a joint research program in Elliott Bay near Seattle, Washington, from November 1975 until December 1976 to determine the effects on indigenous demersal fish and shellfish of dredged material disposal from the Duwamish River in open water. The program was divided into five phases. The first phase (pilot) was to sample all areas in Elliott Bay to aid in the selection of the disposal and reference sites. The second phase (baseline) was to provide background information at the disposal and two reference sites before the dredged material was dumped. The third phase (disposal monitoring) was to study the immediate effects of the dredged material as it was dumped. The fourth phase (postdisposal monitoring) was to determine the delayed effects of disposal of the dredged material. The fifth phase (report writing) provided time to analyze and report the collected data.

Sampling was conducted at each of three test sites (the disposal site and an east and west reference site) prior to disposal of the dredged material, during disposal, and 1 week and 1, 3, 6, and 9 months after disposal. Three replicate trawls were made through each sampling site, each sampling period. The trawl was lowered from the stern of the R/V HAROLD W. STREETER until it was on bottom. It was towed along the bottom near the disposal site or through one of the reference sites for 5 min. The trawl was then retrieved. The total catch (less subsamples for stomach and PCB analysis) was placed in plastic bags and transported to the Northwest and Alaska Fisheries Center in Seattle, Washington, where it was sorted, identified, counted, weighed, and measured. All the data were analyzed statistically to determine if differences in composition and abundance of species were significant and if the differences were attributable to differences among the sampling stations or the sampling periods.

The data were difficult to interpret. Although statistical analysis showed significant differences in both composition and abundance of several species at the three sampling sites, it would be speculative in a short-term study such as this to conclude that those differences were attributable to the effects of dredged material disposal rather than natural population fluctuations caused by seasonal migrations for spawning, feeding, etc. Interpretation was further complicated by the fact that the three test sites were not comparable with respect to bottom sediments, proximity to a source of fresh water, and indigenous species present. The one-point method of dredged material disposal used in this study made it impossible to trawl directly through the disposal site without clogging the trawl, and the time of disposal coincided with the flood stage of the Duwamish River when large volumes of sediment were being carried naturally into Elliott Bay.

It was concluded that the volume of dredged material dumped at the disposal site during this experiment did not have a lasting effect on the composition and abundance of the species present. No variation was detected in the condition of the animals captured at the three different sites. It is recommended that any future studies of this nature include:

- a. Adequate time for complete planning and briefing of all participants before commencing the study.
- b. Adequate time to conduct a thorough site survey to assure selection of comparable disposal and reference sites.
- c. Sufficient time (at least 1 year) for baseline studies to determine seasonal fluctuations in abundance and changes in species composition attributable to behavior patterns.

d. A method of dredged material disposal, both in time and area, more comparable to that used in actual practice so that results might have general application.

e. A longer postdisposal monitoring period, at least for sampling species that do not complete their life cycle in 12 months or less (the duration of this study).



## PREFACE

The work described in this report was performed under Interagency Agreement No. WESRF 7T-22, entitled "Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix A: Effects of Dredged Material Disposal on Demersal Fish and Shellfish," between the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., and the National Marine Fisheries Service (NMFS), Seattle, Wash. The research was sponsored by the Office, Chief of Engineers, U. S. Army, as part of the Dredged Material Research Program (DMRP), which is being managed by the Environmental Laboratory (EL), WES. The study constituted DMRP Work Unit No. 1A10B.

The principal investigator and senior author was John R. Hughes. Warren E. Ames, David A. Misitano, and George F. Slusser, NMFS, assisted both in the field and in the preparation of this report. Special thanks are due the many students from Shoreline Community College, Seattle, Wash., that participated in the study. Particularly helpful were Paul Farley, Larry Ruby, Cindy Kingry, Dee Riff, and Rick Heggen. Dr. Russel Kappenman (NMFS) performed the statistical analysis. George R. Snyder (NMFS) was the project coordinator.

Progress in the study was monitored at WES by Mr. Jeffrey H. Johnson. Manager of the Environmental Criteria Development Project of the DMRP during the study was Dr. Robert M. Engler. Dr. John Harrison was Chief of EL.

Director of WES during the period of the contract and the preparation of the report was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches	0.0254	metres
feet	0.3048	metres
yards	0.9144	metres
miles (U. S. nautical)	1.352	kilometres
cubic yards	0.76456	cubic metres

## PART I: INTRODUCTION

1. The disposal of sediments from normal maintenance dredging of channels and waterways can pose a serious problem (Murphy and Zeigler 1974). During the early history of dredging operations the dredged material was often dumped at any convenient location with little concern for the environment. In more recent times dredged material has been used to create new land masses or expand or improve existing ones. The availability of shore areas where dredged material can be deposited is limited. In many instances it is necessary to dispose of the dredged material at open-water disposal sites.

2. The U. S. Army Corps of Engineers is charged with the responsibility of performing the maintenance dredging required to improve and maintain waterways and navigable channels in the U. S. The Environmental Laboratory (EL) of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., plans and conducts research for the Office, Chief of Engineers, on the disposal of dredged material. The Dredged Material Research Program (DMRP) of EL coordinates research activities to provide definitive information on environmental aspects of dredging and disposal operations. Routine dredging of the Duwamish Waterway, near Seattle, Washington, with open-water disposal of the dredged material into Elliott Bay at the mouth of the river provided an excellent opportunity to supplement ongoing DMRP field studies and to gather valuable environmental data on dredging and disposal operations in Puget Sound.

3. The goals of field investigations of open-water disposal of dredged material from the Duwamish Waterway were to:

a. Determine whether specific chemicals from the dredged material, particularly nutrients, heavy metals, and chlorinated hydrocarbons, are released to the water column during disposal operations.

b. Determine the effect, if any, of dredged material disposal on uptake of polychlorinated biphenyls (PCB's) and heavy metals by important species of demersal fish and shellfish.

c. Determine the effect of dredged material disposal on benthic and demersal faunal abundance and distribution and the rate and extent of benthic recolonization of the disposal site.

4. To accomplish the study goals WES contracted various phases of the research to several agencies and institutions, both public and private. The effect of dredged material disposal on demersal finfish and shellfish communities was studied by the Environmental Conservation Division of the National Marine Fisheries Service (NMFS). The objectives of the research were to: (a) determine the immediate effect of dredged material disposal on fish and shellfish assemblages during the disposal operation, and (b) determine the postdisposal effect of dredged material disposal, in particular the recolonization of the disposal site by demersal fish and shellfish and the subsequent succession of assemblages.

5. In the interest of expediting the completion of this report, no attempt was made to include a comprehensive literature review; however, Smith and Snyder (1976) completed an annotated bibliography on the Duwamish River-Elliott Bay complex with special reference to biological effects of dredged material disposal. Copies of their report are available from the National Marine Fisheries Service, Seattle, Washington. Another literature review that deals in part with the effects of dredged material disposal on marine fish and shellfish was prepared by Lee and Plumb (1974).



## PART II: MATERIALS AND METHODS

### Survey Techniques

6. The 12-month study was divided into five phases:

- I. Pilot survey.
- II. Baseline studies.
- III. Disposal operation monitoring.
- IV. Postdisposal monitoring.
- V. Analyses and report preparation.

7. The primary objective of the pilot survey was to collect data to aid in the selection of a disposal and two reference sites within the study area. Sampling during the pilot survey was conducted in November and December 1975. Thirteen 5-min bottom trawls were made, six along the 100-ft\* contour and seven along the 200-ft contour (Figure 1). The disposal and reference sites were selected as a result of these trawls, along with data provided by other investigating teams.

8. Dredging operations in the Duwamish River began on Feb. 16, 1976, and were completed on Mar. 6, 1976. During this period approximately 150,000 yd<sup>3</sup> of dredged material was discharged near the center of the experimental disposal site. All dredging and disposal operations were accomplished using a clamshell dredge and 500- to 700-yd<sup>3</sup>-capacity barges with bottom-opening doors. The barges were held stationary while the dredged material was dumped. Six individual disposal operations were monitored during Phase III, three each on the 24th and 26th of Feb. 1976.

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\* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 10.

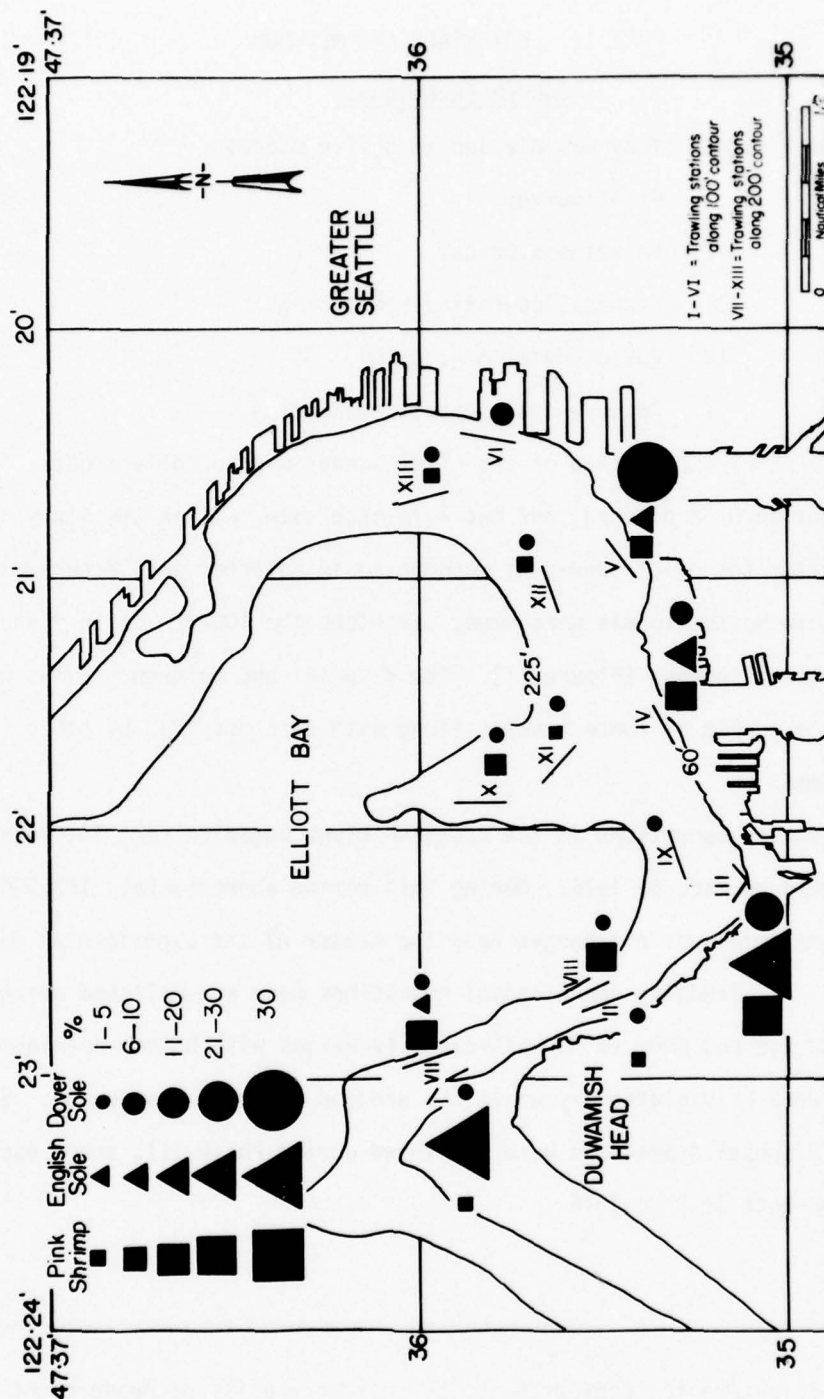


Figure 1. Dominant species concentrations, by trawling site, as determined during the pilot survey

9. Three replicate trawls were made near the disposal site and through each of the reference sites 1 week before disposal, during disposal, 1 week after disposal, and 1, 3, 6, and 9 months after disposal (Table 1). There were seven sample periods so each site was sampled 21 times during the study.

10. All of the trawls were conducted from the NMFS R/V HAROLD W. STREETER. The trawl was a semiballoon otter trawl (Marinovich "try net") having a head-rope 17 ft long and a footrope 21 ft long. The height at the entrance was 2.5 ft. The main body of the net was fabricated of No. 12 twine with a mesh opening of 1-1/4 in. stretched measure. The total length of the net was 30 ft. The cod end was fitted with a knotless nylon liner with a mesh opening of 3/8 in. The trawl doors were 36 in. long and 18 in. high. The towing bridle was 5/8-in.-diameter rope 25 ft long. The towing cable was 7/32-in. stainless steel wire rope. The design and application of similar nets has been reported by Bullis (1961) and Ellis and Stockley (1970).

#### Study Area

11. The study area was located in the southern portion of Elliott Bay, near Seattle, Washington (Figure 2), and is described by McGreevy (1973). The disposal site was located on a delta at the mouth of the Duwamish River in 180 to 200 ft of water. Bottom topography on the delta is of comparatively low relief, and sediments consist of sand, silt, clay, and wood chips.

12. The reference sites were located on either side of Elliott Bay. The east reference site was located off Pier 48 in 150 to 200 ft of water, and the west reference site was located approximately 1000 yd southeast of the Duwamish Head light in 180 to 200 ft of water. The bottom at the east reference site consisted of a silty sand substrate, and the bottom at the west reference site was a sand substrate.

Table 1

Sampling schedule

Study phase	1975-1976												
	D	J	F	M	A	M	J	J	A	S	O	N	D
Pilot study	X												
Baseline			X										
Disposal monitoring				X									
Postdisposal				X	X		X			X			X



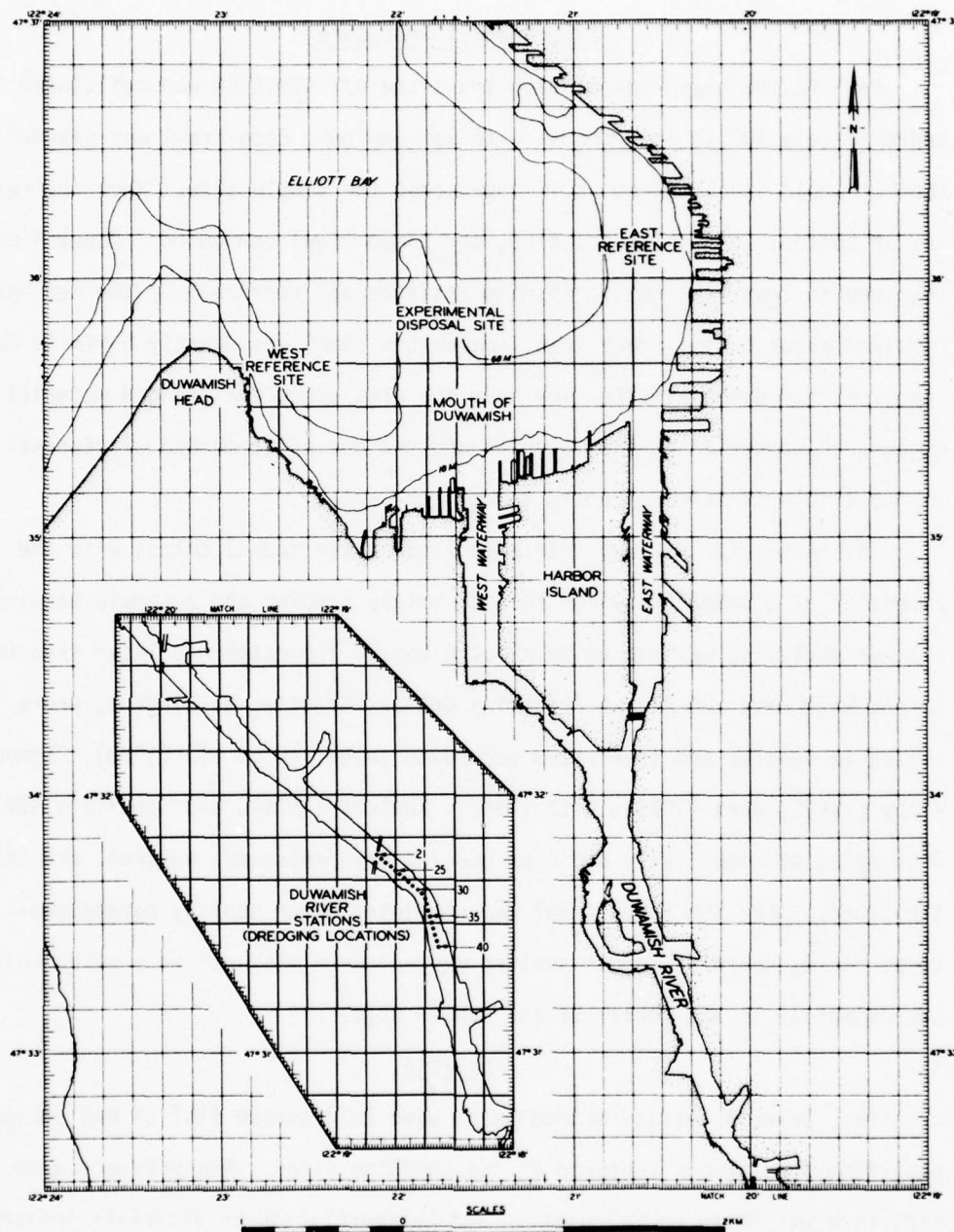


Figure 2. Locations of dredging, disposal, and reference (control) sites. Trawls for demersal assemblages were 5 min in duration through each of the reference sites and near the disposal site

### Experimental Procedure

13. At the beginning of each trawl the R/V STREETER was positioned approximately 300 yd from the area to be sampled. Each trawl was planned so the net would touch bottom as it approached the sample site. When the net was on bottom, in fishing position, the timed trawl commenced. About 5 min was required to lower the net to fishing position and retrieval of the net usually required about 5 min. Each trawl (on-bottom time) was exactly 5 min in duration. Trawls at the disposal site were near the area where the dredged material was dumped. Composition of the material and the one-point method of disposal made it impossible to trawl directly through the site.

14. After the net was retrieved, the entire faunal catch, with the exception of a sample required for PCB uptake studies and a sample required for stomach analysis, was placed in plastic bags. The catch was later transferred to the Northwest and Alaska Fisheries Center, Seattle, Washington, where it was sorted to species and identified according to Bailey et al. (1970), Clemens and Wilby (1967), Hart (1973), Hitz (1965), Kozloff (1974), and Schultz (1936). Subsamples of numerically dominant species were measured, weighed, and the data tabulated. When the third trawl was complete, water quality parameters--temperature, salinity, and dissolved oxygen--were measured in a water column approximately at the center of the sample site.

### Analysis

15. Several testing methods were used to describe finfish and decapod shellfish populations captured at the sampling sites. Analysis of community structure was based on calculation and interpretation of diversity indices. Diversity is useful for comparing temporal community change and results between researchers studying other areas (Mearns 1975). Dahlberg and Odum (1970) note that "Species numbers diversity is generally a more sensitive and reliable

index of environmental health than are individual 'indicator' organisms." The Shannon-Weaver information theory (Shannon and Weaver 1963) ranges from low (0) to high (5.4) diversity as both the number of species and equitability of species abundance increase. The formula used was:

$$H' = -\sum_{i=1}^s p_i \ln p_i = \frac{\ln N - \sum_{i=1}^s \frac{\ln n_i}{N}}{N}$$

where:  $H'$  = diversity index  
 $p_i$  = proportion of the  $i$ -th species in the sample  
 $n_i$  = number of individuals of species,  $i$   
 $N$  = total number of individuals for all species  
 $s$  = number of species

16. A two-factor analysis of variance (Neter and Wasserman 1974) was performed to test for significant spatial and/or temporal variations of the diversity indices calculated by the preceding formula.

17. Results of analysis of variance tests that revealed statistically significant differences of diversity indices among the sampling sites and/or sampling times were examined further using J.W. Tukey's multiple comparison method (Snedecor 1956).

18. An analysis of variance was performed on each of six species of numerically dominant finfish and one decapod shellfish\* to determine if there were significant differences ( $p=0.01$ ) in catches of certain species between sampling sites and between sampling times and the interaction among sampling sites and time. In each analysis the transformation  $\sqrt{x+1}$  was used because the analysis was based on numerical counts and the counts were sometimes small (Snedecor 1956). An attempt was made to determine the effect of the dredged

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\* Catches of Pandalus jordani and P. borealis were combined in this study and are referred to as pink shrimp.

material disposal on the growth pattern of several species; however, the short duration of the study plus the inconsistency of the catch, both in composition and in abundance (Appendix A') at all the sites, made it impossible to draw valid conclusions regarding growth of specimens.



### PART III: RESULTS

#### Community Structure

19. Table 2 shows the water quality parameters measured at each sampling site during each sampling period after the third trawl was completed. There were no biologically significant differences in the parameters monitored at each of the sites for the duration of the study.

20. A total of 8,787 vertebrates and 17,880 invertebrates were captured in 63 trawls during the study. The vertebrates comprised 46 species and the invertebrates 21 species (Appendix A'). The highest concentration of vertebrates was at the east reference site throughout the study except for the final sampling period in December 1976 when a slightly larger catch was taken at the west reference site (Figure 3). The catch was lower at the disposal site than at either of the two reference sites both before and after disposal occurred. The highest concentration of invertebrates was found at the east reference site during the baseline and disposal periods (Figure 4). After disposal of the dredged material there was a dramatic increase in the number of pink shrimp at the disposal site, but a similar increase also occurred at the west reference site.

21. Vertebrates. Table 3 gives the calculated values of diversity index for the vertebrates captured at each sample site during each sampling period. Species diversity for individual trawls at the three sampling stations varied from a low (0.59) on the third trawl at the disposal site on March 2, 1976, to a high (2.34) on the second trawl at the west reference site on December 7, 1976. Studies by Mearns (1974) and Dahlberg and Odum (1970) indicate a diversity of 2.0 would be considered above average.

22. The results of a two-factor analysis of variance (Neter and Wasserman 1974) to test for significant spatial and/or temporal variations of the H'

Table 2

Water quality parameters measured at each sampling site during each sampling period.

Sampling	Depth metres	EAST REFERENCE			DISPOSAL SITE			WEST REFERENCE		
		Temperature °C	Dissolved oxygen ppm	Salinity ppt	Temperature °C	Dissolved oxygen ppm	Salinity ppt	Temperature °C	Dissolved oxygen ppm	Salinity ppt
		(D)* (A)**	(D) (A)	(D) (A)	(D) (A)	(D) (A)	(D) (A)	(D) (A)	(D) (A)	(D) (A)
Feb 11	surface	7.5	9.0	23.3	7.5	9.5	29.2	7.5	9.1	27.3
	10	7.5	8.4	27.6	8.0	8.4	29.2	7.5	8.4	27.6
	20	7.5	8.2	27.6	8.0	8.0	29.2	7.5	7.9	27.6
	30	7.5	7.7	27.6	8.0	7.9	28.4	7.5	7.6	27.6
	40	7.5	7.6	27.6	8.0	7.5	28.4	8.0	7.3	27.6
	50	7.5	7.3	27.6	8.0	7.4	28.4	8.0	7.1	27.6
	60	8.0	7.0	27.6	8.0	7.2	28.4	8.0	7.0	27.6
Mar 2	surface	6.5	6.9	26.3	7.0	6.9	29.2	6.9	7.2	28.0
	10	6.5	7.3	28.3	7.0	7.3	29.2	7.0	7.0	28.4
	20	7.0	7.3	28.3	7.0	7.3	28.4	7.0	6.9	28.4
	30	7.0	7.2	28.3	7.0	7.3	28.4	7.2	6.8	28.4
	40	7.0	7.2	28.3	7.0	7.3	28.4	7.4	6.7	28.4
	50	7.2	7.4	28.3	7.2	7.3	28.4	7.4	6.7	28.4
	60	7.4	7.4	28.3	7.2	7.2	28.4	7.4	6.6	28.4
Mar 22	surface	7.5	11.8	24.6	7.5	11.4	27.3	7.2	12.2	27.6
	10	7.5	10.7	28.3	7.5	11.2	29.2	7.3	11.7	28.0
	20	7.5	10.6	28.3	7.3	11.0	28.8	6.9	11.1	27.5
	30	7.5	10.4	28.3	7.4	11.0	28.4	7.3	10.9	28.0
	40	7.4	10.1	28.3	7.3	10.9	28.4	7.3	10.9	28.0
	50	7.4	10.0	28.3	7.3	10.7	28.4	7.3	10.6	28.0
	60	7.3	10.2	28.3	7.2	10.6	28.4	7.3	10.5	27.6

(Continued)

\* (D) readings taken while probe descending.

\*\* (A) readings taken while probe ascending.

Table 2 (Concluded)

Sampling	Depth metres	EAST REFERENCE				DISPOSAL SITE				WEST REFERENCE			
		Temperature °C		Dissolved oxygen ppm		Temperature °C		Dissolved oxygen ppm		Temperature °C		Dissolved oxygen ppm	
		(D)	(A)	(D)	(A)	(D)	(A)	(D)	(A)	(D)	(A)	(D)	(A)
Apr 12	surface	9.5	9.1	5.9	6.4	17.6	17.0	8.4	8.0	19.4	24.1	8.7	8.5
	10	8.2	7.8	5.8	6.0	28.4	28.4	8.0	7.7	29.2	28.4	8.0	7.8
	20	7.9	7.5	5.9	5.9	28.4	28.4	7.6	7.5	29.2	28.4	7.9	7.6
	30	7.8	7.5	5.9	5.8	28.4	28.4	7.5	7.5	29.2	28.4	7.7	7.5
	40	7.6	7.4	5.8	5.8	28.4	28.4	7.5	7.4	29.2	28.4	7.5	7.5
	50	7.5	7.3	5.8	5.6	28.4	28.4	7.4	7.4	29.2	28.4	7.5	7.5
June 14	surface	12.3	12.0	11.3	9.1	19.8	19.4	10.5	10.3	27.5	27.3	13.5	12.0
	10	9.8	9.6	10.4	8.8	29.8	29.7	9.8	9.5	29.7	29.2	10.5	9.7
	20	9.0	9.5	10.8	8.5	29.7	27.3	9.6	9.5	29.7	29.2	10.2	9.6
	30	9.5	9.4	10.8	8.4	29.2	29.2	9.5	9.3	29.7	29.2	10.2	9.6
	40	9.5	9.4	10.6	8.2	29.2	23.3	9.7	9.0	29.7	29.7	10.0	9.7
	50	9.5	9.5	10.0	9.0	23.0	23.0	9.0	9.0	29.7	29.7	9.7	9.7
Sept 15	surface	13.0	13.0	5.5	5.7	27.6	28.4	12.8	12.5	29.2	29.2	13.0	12.3
	10	12.0	12.0	5.1	5.4	30.6	30.4	12.1	11.8	30.5	30.3	12.0	11.7
	20	11.8	11.8	5.1	5.2	30.5	31.4	11.9	11.7	30.3	30.3	11.7	11.5
	30	11.8	11.7	5.1	5.0	30.5	30.5	11.7	11.7	30.3	30.3	11.5	11.5
	40	11.7	11.5	5.0	4.8	30.5	30.5	11.7	11.5	30.3	30.3	11.5	11.5
	50	11.5	11.2	4.7	4.5	30.5	30.5	11.5	11.5	30.3	30.3	11.4	11.4
Dec 7	surface	9.9	9.8	7.0	6.2	27.6	30.1	9.9	9.9	30.3	30.4	10.0	10.0
	10	10.0	9.9	6.1	6.0	30.6	30.5	10.0	10.0	30.5	30.3	10.0	10.0
	20	10.0	9.9	5.9	5.9	30.6	30.5	10.0	10.0	30.5	30.3	10.0	10.0
	30	10.0	9.9	5.9	5.9	30.6	30.5	10.0	9.9	30.5	30.5	10.0	9.9
	40	10.0	10.0	5.8	5.8	30.5	30.3	10.0	9.9	30.5	30.5	10.0	9.9
	50	10.0	10.0	5.8	5.8	30.5	30.5	10.0	9.9	30.3	30.5	10.0	9.9
June 14	surface	12.3	12.0	11.3	9.1	19.8	19.4	10.5	10.3	27.5	27.3	13.5	12.0
	10	9.8	9.6	10.4	8.8	29.8	29.7	9.8	9.5	29.7	29.2	10.5	9.7
	20	9.0	9.5	10.8	8.5	29.7	27.3	9.6	9.5	29.7	29.2	10.2	9.6
	30	9.5	9.4	10.8	8.4	29.2	29.2	9.5	9.3	29.7	29.2	10.2	9.6
	40	9.5	9.4	10.6	8.2	29.2	23.3	9.7	9.0	29.7	29.7	10.0	9.7
	50	9.5	9.5	10.0	9.0	23.0	23.0	9.0	9.0	29.7	29.7	9.7	9.7
Sept 15	surface	13.0	13.0	5.5	5.7	27.6	28.4	12.8	12.5	29.2	29.2	13.0	12.3
	10	12.0	12.0	5.1	5.4	30.6	30.4	12.1	11.8	30.5	30.3	12.0	11.7
	20	11.8	11.8	5.1	5.2	30.5	31.4	11.9	11.7	30.3	30.3	11.7	11.5
	30	11.8	11.7	5.1	5.0	30.5	30.5	11.7	11.7	30.3	30.3	11.5	11.5
	40	11.7	11.5	5.0	4.8	30.5	30.5	11.7	11.5	30.3	30.3	11.5	11.5
	50	11.5	11.2	4.7	4.5	30.5	30.5	11.5	11.5	30.3	30.3	11.4	11.4
Dec 7	surface	9.9	9.8	7.0	6.2	27.6	30.1	9.9	9.9	30.3	30.4	10.0	10.0
	10	10.0	9.9	6.1	6.0	30.6	30.5	10.0	10.0	30.5	30.3	10.0	10.0
	20	10.0	9.9	5.9	5.9	30.6	30.5	10.0	10.0	30.5	30.3	10.0	10.0
	30	10.0	9.9	5.9	5.9	30.6	30.5	10.0	9.9	30.5	30.5	10.0	9.9
	40	10.0	10.0	5.8	5.8	30.5	30.3	10.0	9.9	30.5	30.5	10.0	9.9
	50	10.0	10.0	5.8	5.8	30.5	30.5	10.0	9.9	30.3	30.5	10.0	9.9

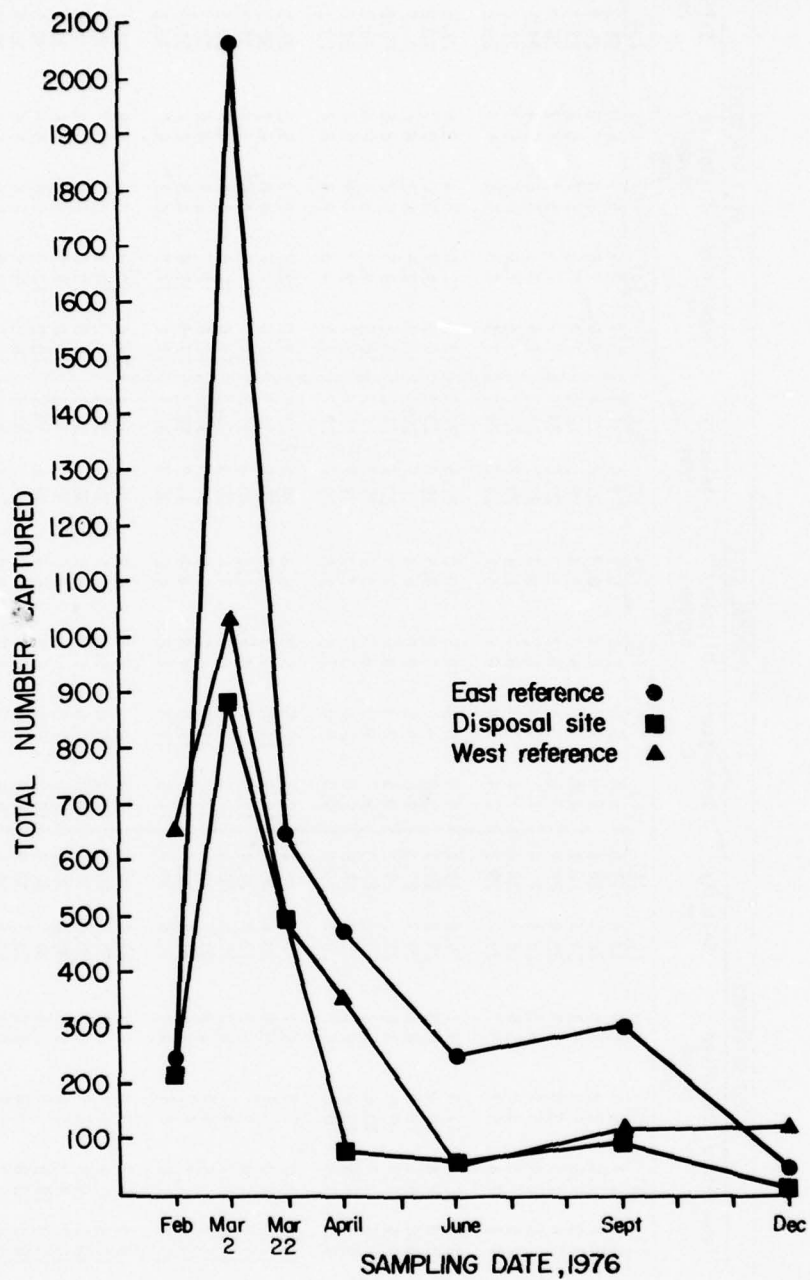


Figure 3. Relative abundance and seasonal variation of vertebrates (all species) at disposal and reference sites



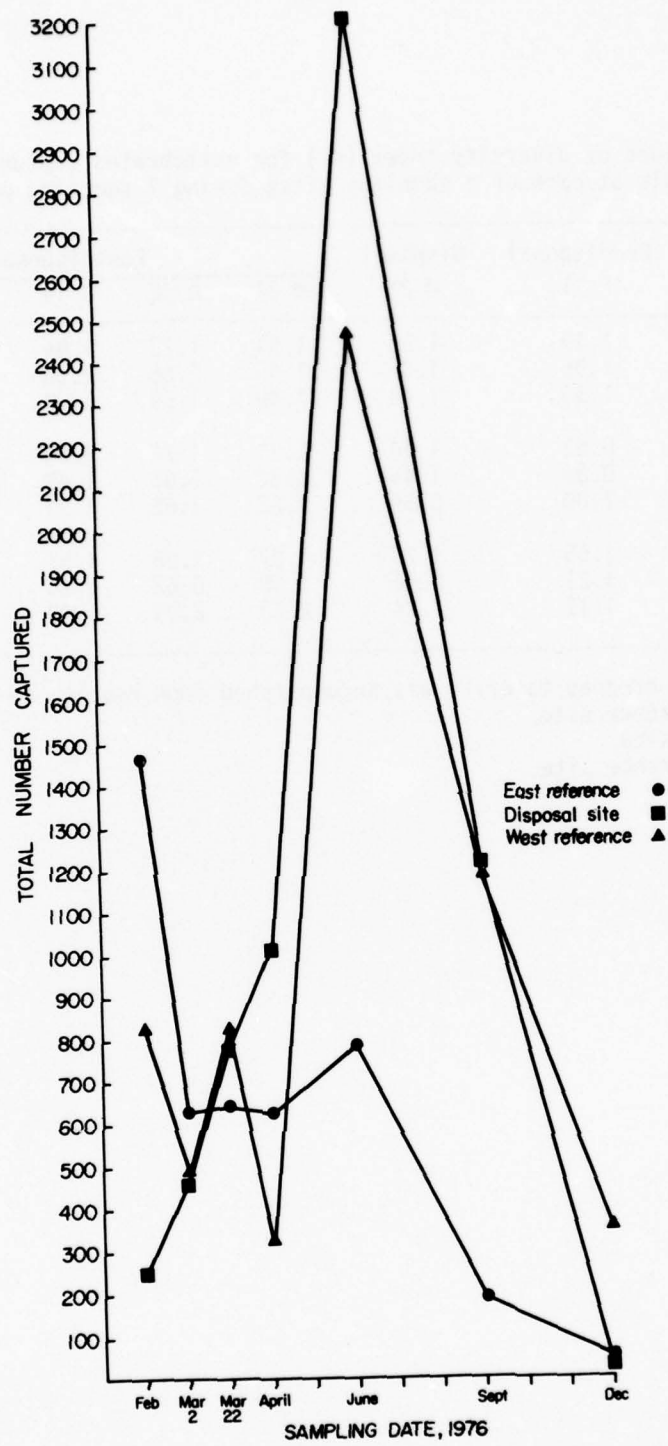


Figure 4. Relative abundance and seasonal variation of invertebrates (all species) at disposal and reference sites

Table 3

Calculated values of diversity index ( $H'$ ) for vertebrates captured during 3 replicate trawls at each of 3 sampling sites during 7 sampling periods

Site	Trawl	Predisposal	Disposal	Postdisposal				
		F 11	M 2*	M 22	A 12	J 14	S 14	D 7
ER	1	1.19	1.25	1.81	1.72	1.84	1.69	1.79
	2	1.96	1.64	1.45	1.66	1.68	1.59	1.88
	3	1.55	1.18	1.40	1.59	1.59	1.65	1.87
D	1	0.63	1.34	1.21	1.72	1.24	1.55	1.76
	2	0.88	1.45	1.32	1.35	1.48	1.88	0.69
	3	1.00	0.59	1.22	1.68	1.27	1.81	0.80
WR	1	1.55	1.73	1.97	1.98	1.51	1.37	1.95
	2	1.21	2.01	1.58	0.62	1.55	2.24	2.34
	3	1.12	1.74	2.13	2.09	1.97	2.06	2.11

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

values presented in Table 3 are given in Table 4. The analysis shows there were significant differences in species diversity of vertebrates captured at the three sampling sites that can be attributed to differences among the sites and to differences among the sampling times. Apparently, there were no differences in species diversity of vertebrates captured attributable to interactions between sites and sampling times, i.e., temporal changes were similar at all sites.

23. The intervals for the differences among the mean site diversity indices calculated using the Tukey multiple comparison method (Snedecor 1956) are:

East reference site and disposal site	(0.10, 0.57)
West reference site and disposal site	(0.23, 0.71)
East reference site and west reference site	(-0.10, 0.37)

24. The estimated average values of the diversity indices for the three sites are:

East reference site	1.62
Disposal site	1.28
West reference site	1.75

25. Examination of the intervals associated with the Tukey comparison test shows that both the east and west reference sites differed from the disposal site because neither of the pertinent intervals contain the point zero. Inspections of the mean diversity indices for each of the sites show that the east and west reference sites are similar but that both differ from the disposal site.

26. The estimated average values of diversity indices for the seven sampling periods are:

Table 4

Analysis of variance of differences among diversity index (H') values for the vertebrates captured by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	1.25	12.34*
Time	6	0.27	2.67**
Interaction	12	0.15	1.51
Error	42	0.10	

\* Statistically significant at the 0.01 level of significance.

\*\* Statistically significant at the 0.05 level of significance.



Feb = 1.23

Mar = 1.44

Mar = 1.57

Apr = 1.60

Jun = 1.57

Sep = 1.76

Dec = 1.69

These values indicate that with the exception of the initial sampling period in February 1976, the diversity indices for vertebrates, with respect to sampling times, were similar.

27. Invertebrates. Table 5 gives the calculated values of the diversity index for invertebrates captured for each trawl at each sampling site for each sampling period. Species diversity for individual trawls at the three sampling stations varied from a low (0.0) on 5 individual trawls on 3 different sampling dates at each of the sampling sites to a high (1.53) on the third trawl at the west reference site on December 7, 1977. The 0.0 species diversity indicates that only one invertebrate species was captured in that particular trawl. The 1.53 species diversity represents 7 species captured.

28. The results of an analysis of variance of the diversity index values presented in Table 5 are shown in Table 6. The analysis shows there was a significant difference in species diversity of invertebrates attributable to differences among the sampling sites and to differences among the sampling periods. Interaction among the sites and sampling times was not significant, indicating that temporal changes were similar at all stations.

29. Intervals for the differences in site mean diversity indices associated with the Tukey multiple comparison procedure are:

Table 5

Calculated values of diversity index ( $H'$ ) for invertebrates captured during 3 replicate trawls at each of 3 sampling sites during 7 sampling periods

Site	Trawl	Predisposal	Disposal	Postdisposal				
		F 11	M 2*	M 22	A 12	J 14	S 14	D 7
ER	1	0.87	0.0	0.66	0.99	0.73	0.90	1.32
	2	0.80	0.91	0.90	0.87	0.92	0.0	1.31
	3	1.01	0.43	0.92	1.03	0.92	0.09	0.92
D	1	0.45	1.24	0.42	0.15	0.14	0.01	0.85
	2	0.57	0.89	0.55	0.57	0.22	0.0	0.0
	3	0.73	0.56	0.64	0.80	0.23	0.01	0.41
WR	1	0.78	0.58	0.44	0.73	0.42	0.06	0.47
	2	0.90	0.58	0.76	0.85	0.12	0.0	1.53
	3	0.36	0.63	0.42	0.67	0.50	0.09	0.31

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

Table 6

Analysis of variance of differences among diversity index ( $H'$ ) values for the invertebrates captured by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	0.64	8.47*
Time	6	0.46	6.16*
Interaction	12	0.12	1.58
Error	42	0.07	

\* Statistically significant at the 0.01 level of significance.

East reference site and disposal site (0.12, 0.54)

West reference site and disposal site (-0.12, 0.29)

East reference site and west reference site (0.04, 0.45)

30. Since no zero point is evident in the comparison of the east reference site with either the disposal site or the west reference site, it appears the community structure of invertebrates at the east reference site was different than at the two other sites. The point zero in the interval comparison of the west reference site with the disposal site indicates that the invertebrate community structure at these two stations was similar.

31. The estimated average values of diversity indices for the three sites are:

East reference site = 0.79

Disposal site = 0.45

West reference site = 0.53

Examination of these values shows that the disposal site and the west reference site were similar with respect to diversity of invertebrates captured, but both differed from the east reference site.

32. The estimated average values of diversity indices for the seven sampling periods are:

Feb = 0.72

Mar = 0.65

Mar = 0.64

Apr = 0.74

Jun = 0.47

Sep = 0.13

Dec = 0.79



These values show a variation in species diversity of invertebrates captured in June and September as compared with the other sampling periods, i.e., there were temporal differences.

#### Species Population

33. Six of the most abundant vertebrates, English sole (Parophrys vetulus), Dover sole (Microstomus pacificus), flathead sole (Hippoglossoides elassodon), Rex sole (Glyptocephalus zachirus), shiner perch (Cymatogaster aggregata), and plainfin midshipman (Porichthys notatus), and the most abundant decapod invertebrate, pink shrimp (Pandalus borealis and P. jordani)\*, were selected for more thorough statistical treatment.

34. English sole. One thousand five hundred and seventy-four English sole (Barss 1976) were captured during the experiment. By far the majority were taken during the first three sampling periods (Feb 11, Mar 2, and Mar 22) and almost one half during the second sampling period (Figure 5). The largest catches were at the disposal site and the next highest catches were at the west reference site. Only 2 were captured during the June sampling and only 10 each in September and December. Table 7 shows the number of English sole captured at each sampling station, by trawl, for each sampling period.

35. Analysis of variance for the catch of English sole between sampling sites and sampling times (Table 8) shows there were significant differences in numbers of English sole captured with respect to differences among the sites, differences in sampling time, and interaction among sites and time.

36. Dover sole. The Dover sole (Demory 1975) is another commercially important finfish that was captured in relatively large numbers in Elliott Bay.

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\* The catches of P. borealis and P. jordani were combined and are referred to as pink shrimp in this report.

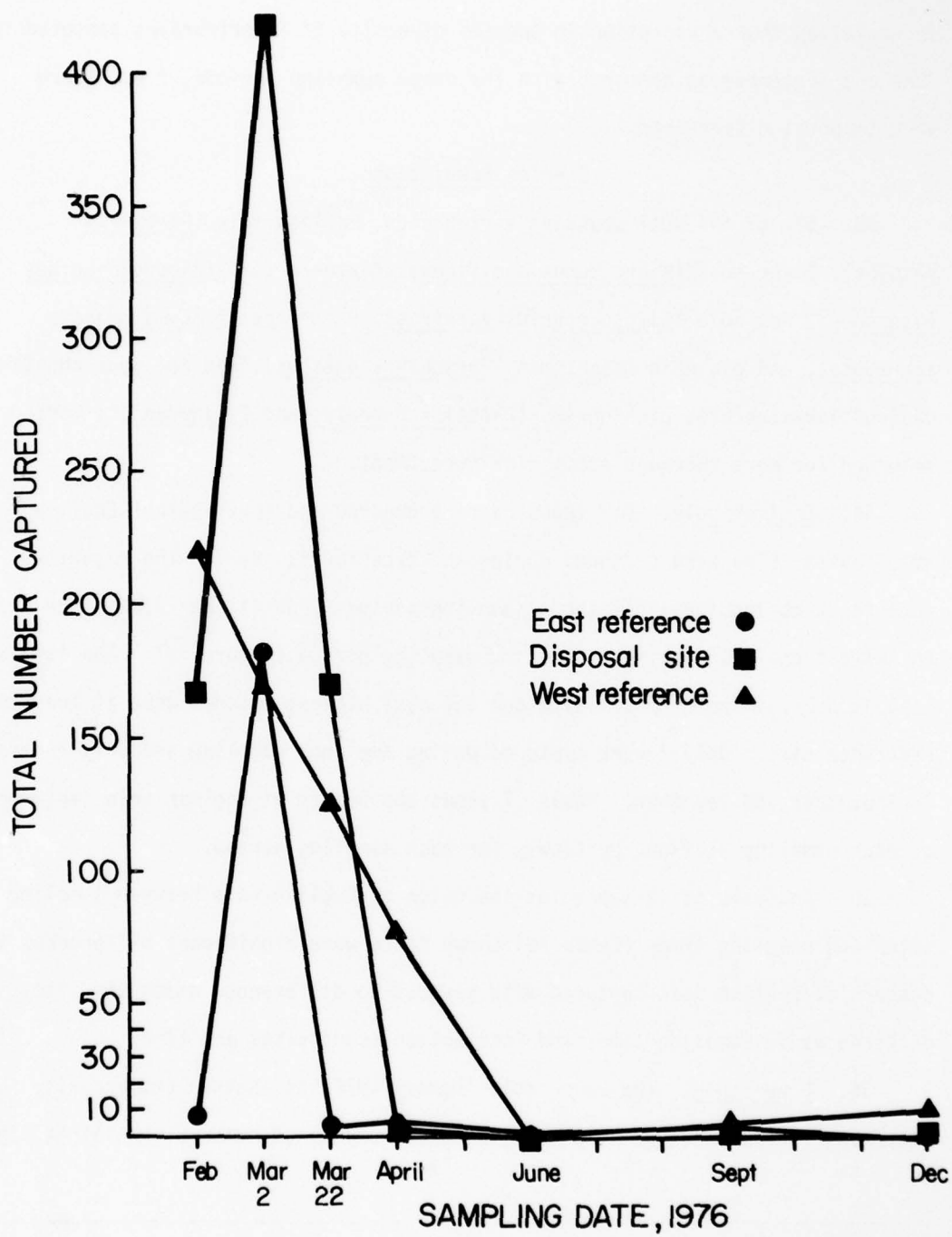


Figure 5. Relative abundance and seasonal variation of English sole (*Parophrys vetulus*) at disposal and reference sites

Table 7

Numbers of English sole (*Parophrys vetulus*) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal					Total
		F	M <sub>2</sub> *	M <sub>22</sub>	A	J	S	D	
ER	1	3	28	2	1	0	1	0	202
	2	4	124	1	4	1	1	0	
	3	0	30	0	0	0	2	0	
	Total	7	182	3	5	1	4	0	
D	1	89	47	80	1	0	0	0	757
	2	57	110	85	0	0	0	0	
	3	21	261	5	0	0	1	0	
	Total	167	418	170	1	0	1	0	
WR	1	96	59	65	42	1	4	1	615
	2	83	65	42	6	0	0	7	
	3	41	53	18	29	0	1	2	
	Total	220	177	125	77	1	5	10	
Total		394	777	298	83	2	10	10	1,574

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

Table 8

Analysis of variance of catches of English sole (Parophrys vetulus) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	33.66	10.62*
Time	6	76.28	24.04*
Interaction	12	10.04	3.16*
Error	42	3.16	

\* Statistically significant at the 0.01 level of significance.



Eight hundred and sixty-nine were taken during the study. Sixty-six percent of the total were taken during the three sampling periods in March and April of 1976 (Figure 6). The largest single catch was on March 2, 1976, at the east reference site when 189 individuals were captured in a single trawl. Table 9 shows the catch at each sampling station, by trawl number and sampling date. Sixty-one percent of the total number captured were taken at the east reference site.

37. Analysis of variance (Table 10) shows that there were significant differences in catch that can be attributed to differences among the three sampling stations and the seven sampling periods. There was no evidence that interaction among the sampling sites and sampling times caused a significant variation in the catch of Dover sole.

38. Flathead sole. Nine hundred and thirty-nine flathead sole were captured during the study. Approximately 89 percent were captured at the east reference site (Figure 7). Only 74 animals (0.08 percent) were taken at the disposal site. Table 11 shows the numbers captured by time, individual trawl, and station. Analysis of variance (Table 12) shows a significant difference in the catch attributable to differences among the stations but no difference in the catch attributable to differences among the sampling times or because of interaction among the sampling sites and sampling time. Although there were significant differences in the catch attributable to differences among the stations, Table 11 shows these differences existed throughout the experiment, both before and after the disposal operation.

39. Rex sole. Four hundred and sixty-five Rex sole (Hosie 1976) were captured during the study (Table 13). Of these, 386 (83 percent) were captured at the east reference site (Figure 8). Analysis of variance (Table 14) shows that the differences in catch attributable to differences among the sites

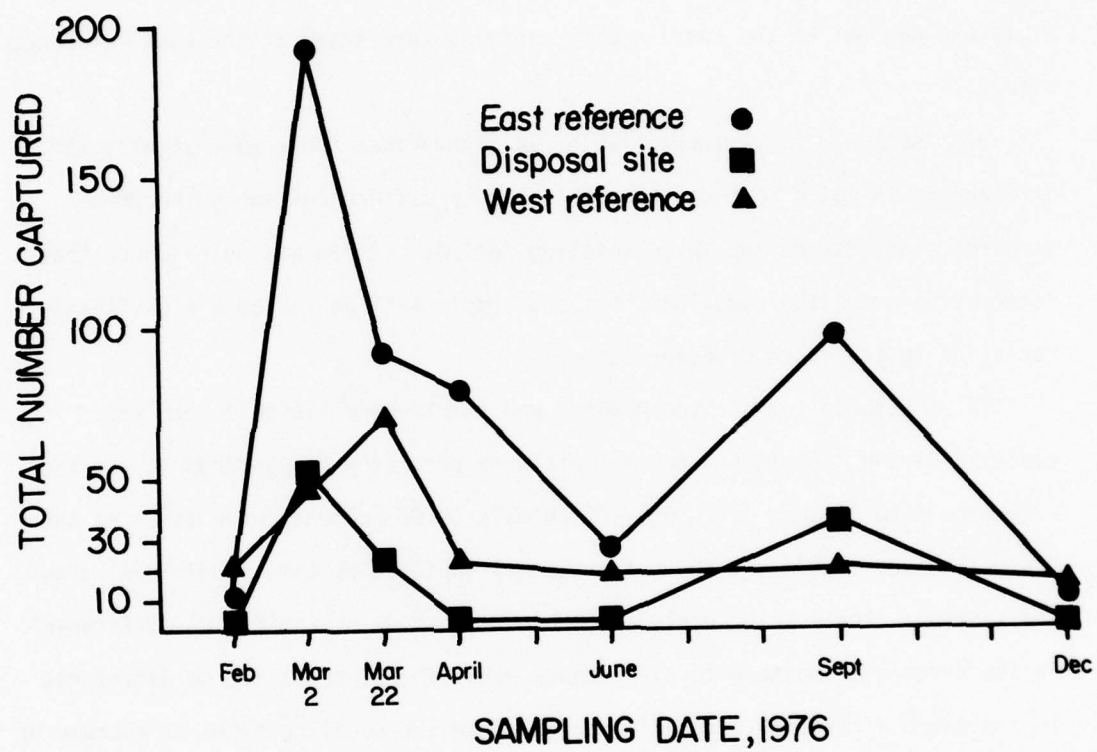


Figure 6. Relative abundance and seasonal variation of Dover sole (*Microstomus pacificus*) at disposal and reference sites

Table 9

Numbers of Dover sole (*Microstomus pacificus*) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal					Total
		F	M <sub>2</sub> *	M <sub>22</sub>	A	J	S	D	
ER	1	2	0	31	29	14	52	1	
	2	2	189	30	30	22	29	5	
	3	8	5	30	21	10	17	5	
	Total	12	194	91	80	46	98	11	532
D	1	0	20	2	1	0	13	1	
	2	2	18	6	2	4	12	0	
	3	0	13	15	1	0	11	0	
	Total	2	51	23	4	4	36	1	121
WR	1	11	16	19	12	6	2	7	
	2	7	18	30	0	7	8	2	
	3	3	14	21	10	6	11	6	
	Total	21	48	70	22	19	21	15	216
Total		35	293	184	106	69	155	27	869

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

Table 10

Analysis of variance of catches of Dover sole (Microstomus pacificus) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	22.87	8.08*
Time	6	11.50	4.06*
Interaction	12	1.97	0.69
Error	42	2.83	

\* Statistically significant at the 0.01 level of significance.



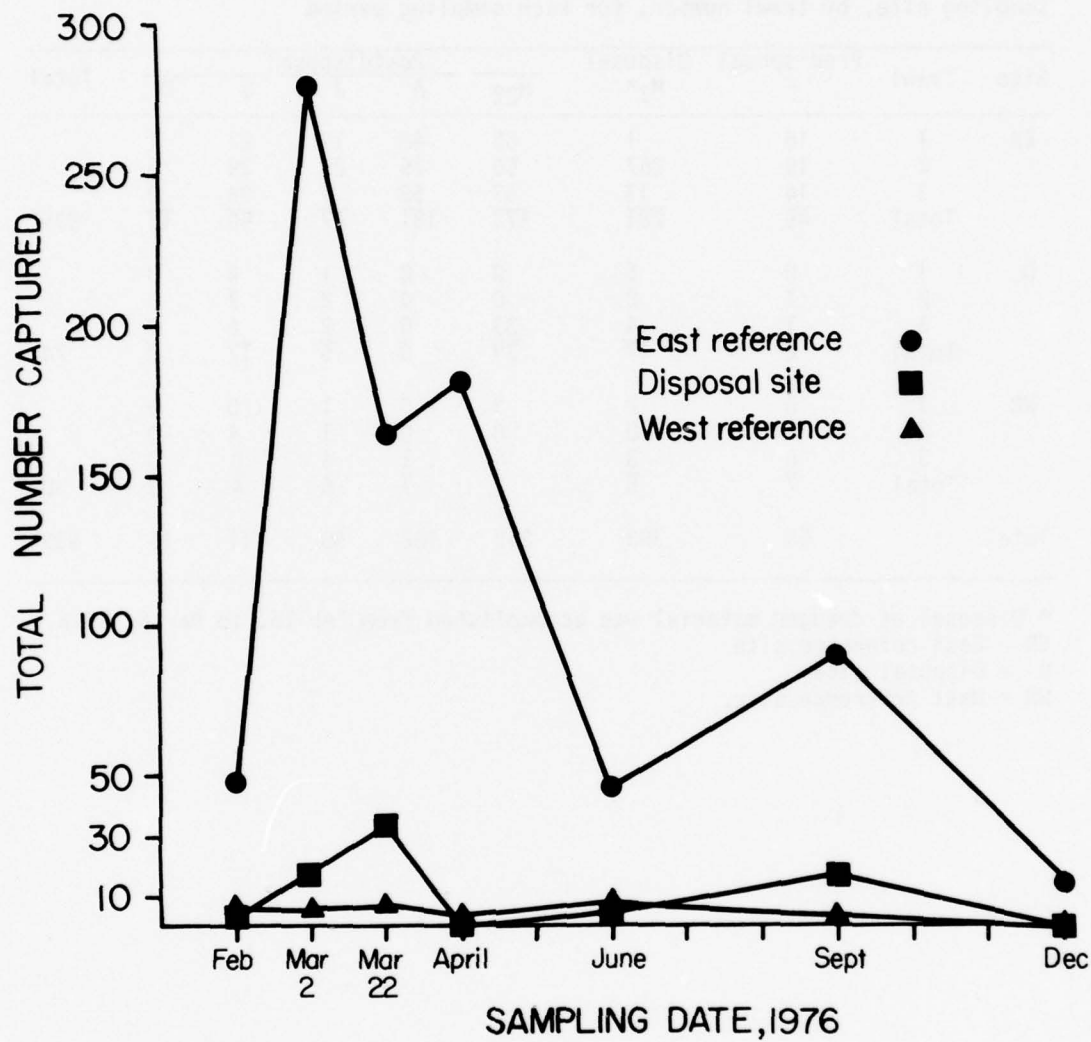


Figure 7. Relative abundance and seasonal variation of flathead sole (*Hippoglossoides elassodon*) at disposal and reference sites

Table 11

Numbers of flathead sole (*Hippoglossoides elassodon*) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal					Total
		F	M <sub>2</sub> *	M <sub>22</sub>	A	J	S	D	
ER	1	16	1	65	48	14	27	1	835
	2	19	267	50	75	26	39	5	
	3	14	13	57	58	7	24	9	
	Total	49	281	172	181	47	90	15	
D	1	0	5	0	0	1	4	0	74
	2	1	8	0	0	2	7	0	
	3	1	4	33	0	2	6	0	
	Total	2	17	33	0	5	17	0	
WR	1	6	2	3	0	1	0	0	30
	2	1	0	0	0	1	4	0	
	3	0	3	4	1	4	0	0	
	Total	7	5	7	1	6	4	0	
Total		58	303	212	182	58	111	15	939

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

Table 12

Analysis of variance of catches of flathead sole (Hippoglossoides elassodon) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	105.98	28.22*
Time	6	7.21	1.92
Interaction	12	4.06	1.08
Error	42	3.75	

\* Statistically significant at the 0.01 level of significance.

Table 13

Numbers of Rex sole (Glyptocephalus zachirus) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal					Total
		F	M <sub>2</sub> *	M <sub>22</sub>	A	J	S	D	
ER	1	1	1	26	28	11	15	0	
	2	4	109	9	21	34	22	4	
	3	8	1	17	38	7	28	2	
	Total	13	111	52	87	52	65	6	386
D	1	0	5	0	0	0	2	0	
	2	0	2	0	0	0	1	0	
	3	0	2	9	0	0	1	0	
	Total	0	9	9	0	0	4	0	22
WR	1	4	2	7	4	0	2	1	
	2	1	1	2	0	0	3	2	
	3	3	4	0	9	4	4	4	
	Total	8	7	9	13	4	9	7	57
Total		21	127	70	100	56	78	13	465

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.



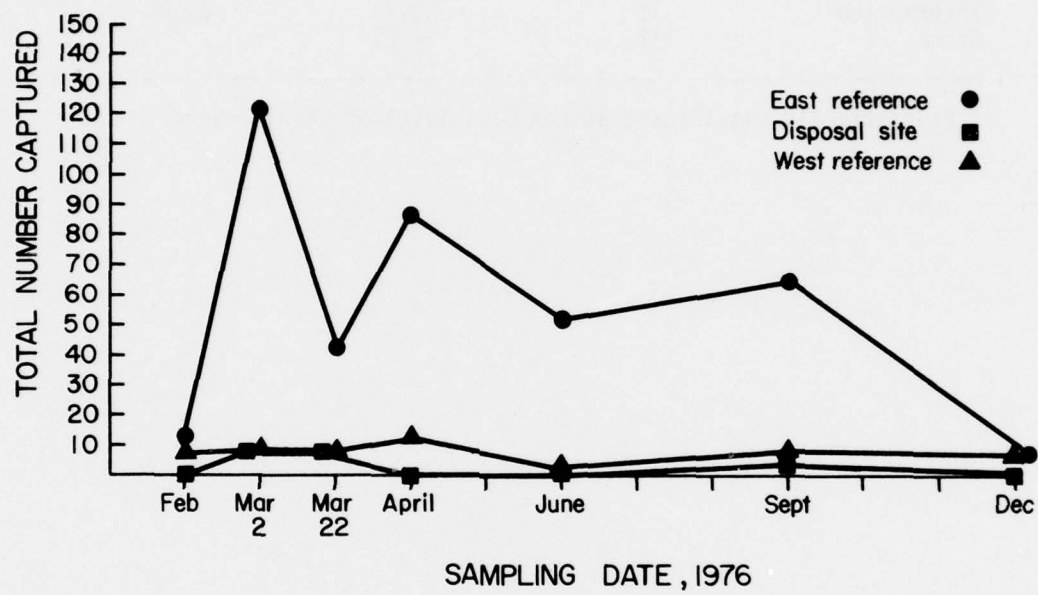


Figure 8. Relative abundance and seasonal variation of Rex sole (*Glyptocephalus zachirus*) at disposal and reference sites

Table 14

Analysis of variance of catches of Rex sole (Glyptocephalus zachirus) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	36.69	20.21*
Time	6	2.73	1.50
Interaction	12	1.78	0.98
Error	42	1.81	

\* Statistically significant at the 0.01 level of significance.

were significant; however, differences in catch attributable to differences among the sampling times or to interaction among the sampling stations and sampling times were not significant. Although analysis of variance shows a significant difference in catch attributable to differences among the stations, the differences existed before the disposal operation as well as after. There does not appear to be any difference in catch between the west reference site and the disposal site with respect to either time or space and no significant difference in catch attributable to interaction of sampling stations and time.

40. Shiner perch. A total of 3151 shiner perch were captured during the study (Table 15). Of these, 3012 (96 percent) were captured during the first three sampling periods (Feb, March, and March), indicating a rather significant fluctuation in seasonal abundance (Figure 9). The large catches were both before and after disposal and at all three sampling sites, indicating that the dumping of the dredged material did not have a significant effect on the immediate distribution of the perch. The declining catches later in the experiment occurred at all three sampling sites, indicating a seasonal variation in abundance rather than a delayed adverse effect from the dredged material disposal.

41. Analysis of variance of the shiner perch catch data (Table 16) reveals that the differences in catch among the seven sampling periods were significant. The differences in catch attributable to differences among the sampling stations or interaction among the stations and time of sampling were not significant.

42. Plainfin midshipmen. Three hundred and thirty-four plainfin midshipmen were captured during the experiment (Table 17). Of these, 190 (57 percent) were captured at the east reference site (Figure 10). These fish appeared to be present during most of the sampling periods; however, the total numbers

Table 15

Numbers of shiner perch (*Cymatogaster aggregata*) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal					Total
		F	M <sub>2</sub> *	M <sub>22</sub>	A	J	S	D	
ER	1	90	5	53	1	0	0	0	1,522
	2	21	1,015	118	5	0	0	0	
	3	8	118	85	2	0	0	1	
	Total	119	1,138	256	8	0	0	1	
D	1	1	260	1	0	0	0	0	512
	2	2	49	6	0	0	5	0	
	3	1	4	183	0	0	0	0	
	Total	4	313	190	0	0	5	0	
WR	1	66	155	60	3	0	0	3	1,117
	2	14	94	105	33	0	0	2	
	3	226	260	12	81	0	0	3	
	Total	306	509	177	117	0	0	8	
Total		429	1,960	623	125	0	5	9	3,151

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

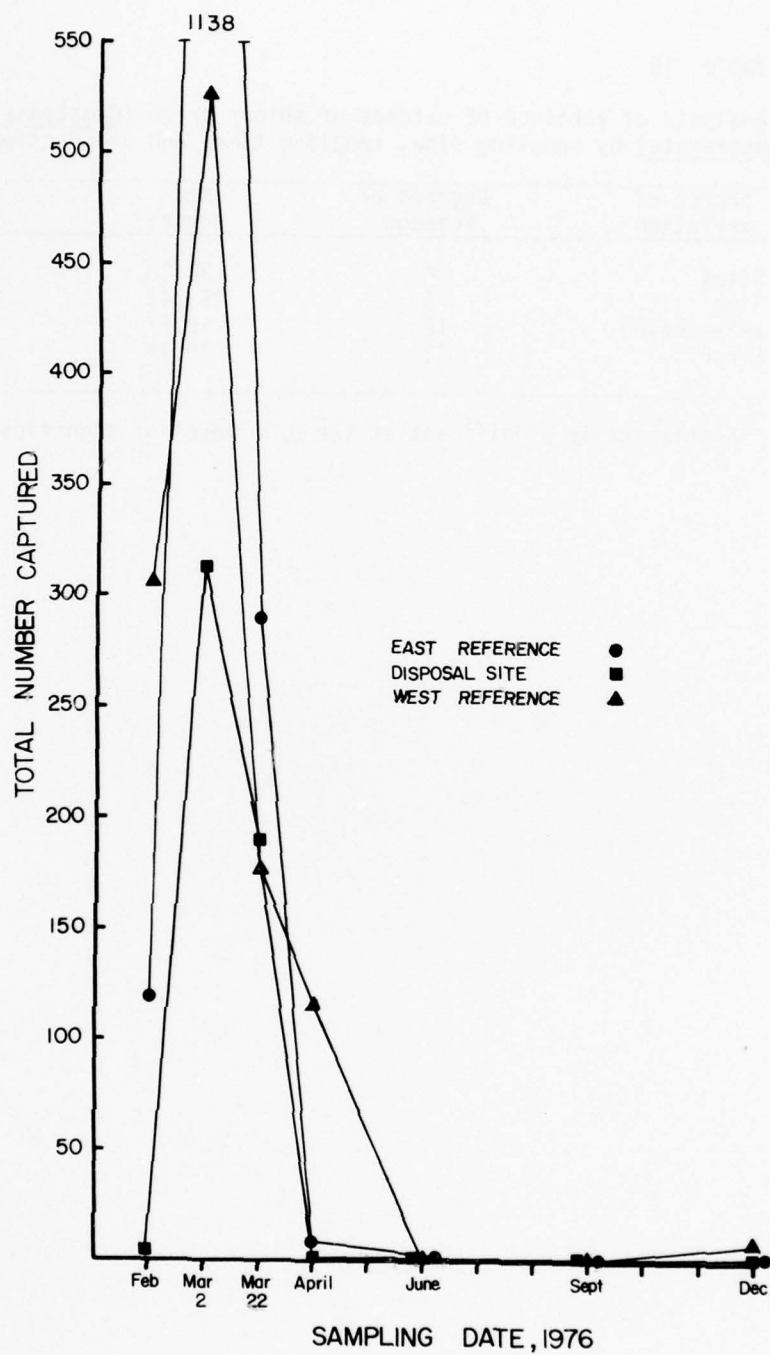


Figure 9. Relative abundance and seasonal variation of shiner perch (*Cymatogaster aggregata*) at disposal and reference sites



Table 16

Analysis of variance of catches of shiner perch (Cymatogaster aggregata) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	38.80	2.02
Time	6	151.43	7.91*
Interaction	12	10.67	0.55
Error	42	19.14	

\* Statistically significant at the 0.01 level of significance.

Table 17

Numbers of plainfin midshipmen (*Porichthys notatus*) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal				Total
		F	M <sub>2</sub> *	M <sub>22</sub>	A	J	S	D
ER	1	4	0	2	16	11	7	1
	2	6	32	3	27	24	7	1
	3	5	1	0	30	9	3	1
	Total	15	33	5	73	44	17	3
D	1	22	3	1	0	0	0	1
	2	1	6	2	0	0	0	1
	3	2	1	0	0	0	2	7
	Total	25	10	3	0	0	2	9
WR	1	5	2	11	0	0	2	1
	2	8	0	2	0	0	1	6
	3	22	4	14	2	0	7	8
	Total	35	6	27	2	0	10	15
Total		75	49	35	75	44	29	27
								334

\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

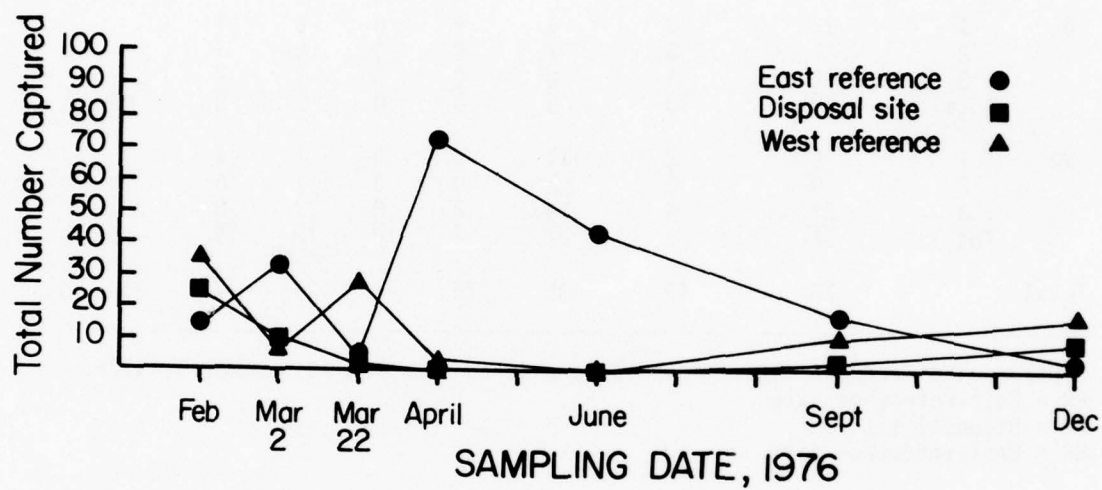


Figure 10. Relative abundance and seasonal variation of plainfin midshipmen (*Porichthys notatus*) at disposal and reference sites

captured during the last two sampling periods (Sep, Dec) were somewhat less than during the earlier sampling periods.

43. An analysis of variance (Table 18) shows that the differences in numbers of plainfin midshipmen captured attributable to differences among the stations and to interaction of sampling times and stations were significant. Differences in catch attributable to differences among the sampling times were not significant.

44. Pink shrimp. A total of 15,013 pink shrimp (Barr 1970, Magoon 1974, Robinson 1976) were captured during the study (Table 19). An analysis of variance (Table 20) shows there were significant differences among the catches attributable to differences among the sampling sites and the sampling times and to interaction between sampling sites and sampling times. Only 2,986 pink shrimp (20 percent) were captured at the east reference site (Figure 11). The remainder of the catch was approximately evenly distributed between the disposal site and the west reference site. The shrimp were most abundant in June when 5,873 were captured (39 percent) and least abundant in December when only 341 were captured (2 percent).

45. Although a rather dramatic increase in abundance of pink shrimp occurred at the disposal site immediately after disposal of the dredged material, there does not appear to be a direct correlation between the disposal and the increase in abundance because a similar increase also occurred at the west reference site. For the most part, the population fluctuations seem more likely to be associated with seasonal fluctuations than with effects of dredged material disposal.

Table 18

Analysis of variance of catches of plainfin midshipmen (Porichthys notatus) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	7.62	8.67*
Time	6	1.07	1.22
Interaction	12	3.61	4.11*
Error	42	0.87	

\* Statistically significant at the 0.01 level of significance.



Table 19

Numbers of pink shrimp\* (Pandalus borealis and Pandalus jordani) captured at each sampling site, by trawl number, for each sampling period

Site	Trawl	Predisposal	Disposal	Postdisposal					Total
		F	M <sub>2</sub> **	M <sub>22</sub>	A	J	S	D	
ER	1	703	53	282	76	212	26	2	2,986
	2	353	358	98	118	221	50	6	
	3	9	23	63	130	88	100	15	
	Total	1,065	434	443	324	521	176	23	
D	1	1	33	180	418	454	455	22	6,246
	2	102	124	370	169	1,527	375	0	
	3	64	97	105	291	1,065	388	6	
	Total	167	254	655	878	3,046	1,218	28	
WR	1	274	136	221	135	544	310	105	5,781
	2	178	133	168	9	1,358	521	20	
	3	205	139	323	83	404	350	165	
	Total	657	408	712	227	2,306	1,181	290	
Total		1,889	1,096	1,810	1,429	5,873	2,575	341	15,013

\* The catches of P. borealis and P. jordani were combined and both species are referred to as pink shrimp in this report.

\*\* Disposal of dredged material was accomplished from Feb 16, to Mar 6, 1976.

ER = East reference site.

D = Disposal site.

WR = West reference site.

Table 20

Analysis of variance of catches of pink shrimp\* (Pandalus borealis and Pandalus jordani) by sampling site, sampling time, and interaction

Source of variation	Degrees of freedom	Mean square	F
Sites	2	142.98	5.77**
Time	6	290.50	11.74**
Interaction	12	80.47	3.25**
Error	42	24.74	

\* The catches of P. borealis and P. jordani were combined and both species are referred to as pink shrimp in this paper.

\*\* Statistically significant at the 0.01 level of significance.

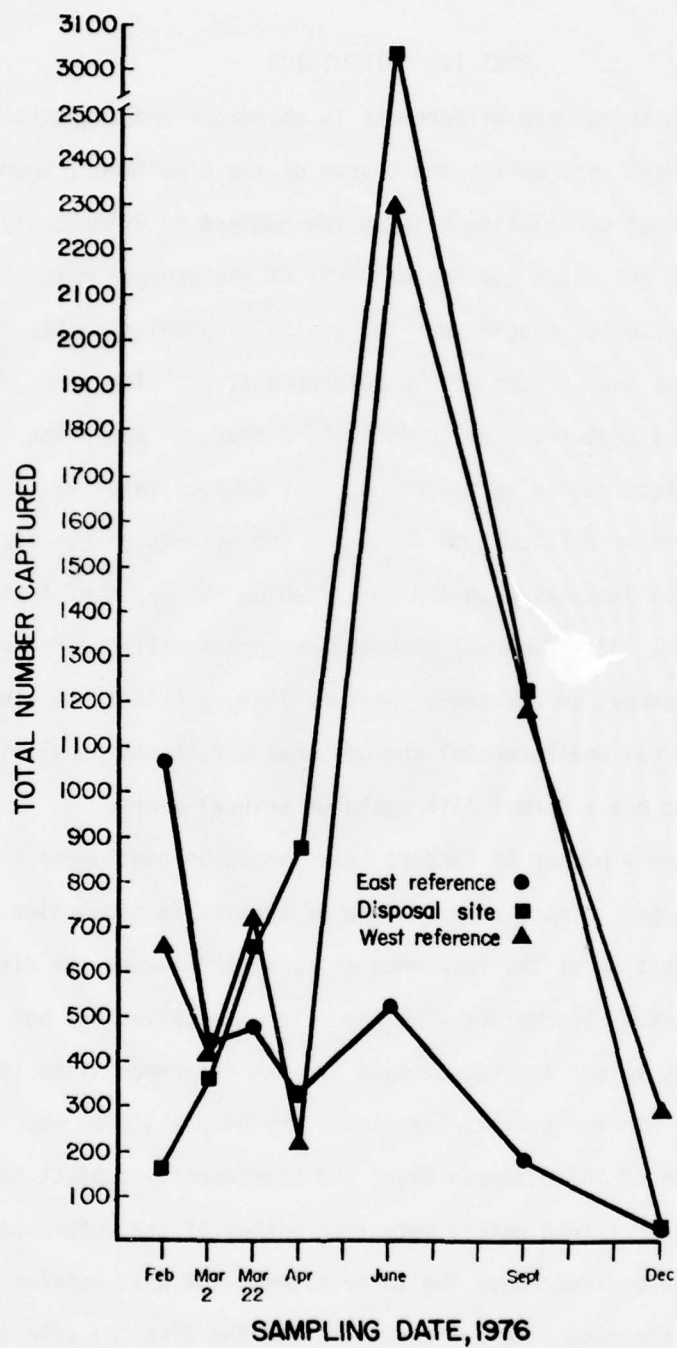


Figure 11. Relative abundance and seasonal variation of pink shrimp (Pandalus borealis and P. jordani) at disposal and reference sites

#### PART IV: DISCUSSION

46. Although there were differences in abundance and composition of the catch at the disposal site during the course of the experiment, there does not appear to be a direct correlation between the numbers of animals captured or the composition of the catch and the disposal of the dredged material. When the catch of a particular species was low at the disposal site the catch was also usually low at one or both of the reference sites. The fluctuations in numbers and species captured seem to indicate a seasonal variation in abundance rather than an effect caused by the disposal of dredged material.

47. It would be difficult to determine the effects of the disposal of dredged material on demersal fish and shellfish on the basis of a short-term study such as this. Most demersal fish and decapod shellfish are cyclic in population and seasonal in abundance (Matsuda 1974). A 12-month study does not allow for the natural environmental changes that affect the population of any given species that has a normal life cycle of several years.

48. There are a number of factors that should be considered in designing a study of this type. First, correlations of changes in population abundance and species composition at the reference sites with those at the disposal site provide little useful information when the sites themselves are not similar. It is difficult to select a disposal site and two reference sites that are truly comparable. In the Elliott Bay study, the disposal site was located close to the mouth of the Duwamish River and consequently subject to the effects of the river (fresh water) more than either of the reference sites. The bottom sediments differed at the three sites. The west reference site was sandy, the east reference site mud and silt, and the disposal site a combination of silt, wood chips, and rubble washed from the Duwamish River. Consequently, one would not expect the demersal fish and shellfish populations at the three sites to be similar.

49. Second, the method used to dispose of the dredged material made it impossible to sample the immediate area at the disposal site. The dredged material was transported to the disposal site and the barge held stationary while the material was dumped. This method resulted in a mound that was impossible to trawl through and unrealistic to evaluate because a moving barge that creates a scattering effect is the normal method used when dumping dredged material.

50. Third, the time of dumping corresponded with the flood period of the Duwamish River. It was apparent that perhaps as much sediment was being transported into Elliott Bay by the flooding of the Duwamish River as was dumped by the barges (Edmonson 1973). Visual observations showed that the sediment load from the Duwamish River was affecting all three sites but probably the disposal site and the east reference sites the most because of normal current patterns.



#### PART V: CONCLUSIONS AND RECOMMENDATIONS

51. Nothing in the study data indicates that the quantity and type of material dredged from the Duwamish River and dumped at the experimental disposal site in Elliott Bay had a long-lasting adverse affect on demersal fish and decapod shellfish populations. The study did show fluctuations in population abundance and composition of species at all of the sampling sites but the changes were probably due to seasonal variation rather than to effects of the dredged material.

52. It is suggested that any similar future studies be planned and discussed with all participants thoroughly, and that all aspects of experimental design and data analysis be established prior to the start of the experiment. More time should be devoted toward gathering background and baseline information--perhaps 1 year would be adequate. The disposal site and reference sites should be as similar as possible in every detail. The dredged material should be dumped following a technique used in practical applications, so the results of the study might have general application. The experiment should be carried out for at least 2 or 3 years to allow for cyclic fluctuations in populations and seasonal variation in abundance. Perhaps the study might be more realistic if periodic disposals of the dredged material were made rather than disposal of all the material in 2 or 3 weeks.

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APPENDIX A': TOTAL CATCH OF DEMERSAL VERTEBRATES  
AND INVERTEBRATES BY SPECIES AND INDIVIDUAL TRAWL  
AT EACH SAMPLING STATION FOR EACH SAMPLING PERIOD

Table A1

Total Catch of Demersal Vertebrates and Invertebrates by Species and Individual Trawl at Each Sampling Station for Each Sampling Period

Species	February 11, 1976					February 13, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>VERTEBRATES</u>										
English sole	3	4	--	7	2.3	89	57	21	167	55.7
<i>P. vetulus</i>	--	--	--	--	--	--	--	1	1	0.3
Rock sole	2	10	--	12	4.0	1	1	--	2	0.7
<i>L. bilineata</i>	2	2	8	12	4.0	--	2	--	2	0.7
<i>L. exilis</i>	16	19	14	49	16.3	--	1	1	2	0.7
Dover sole	1	4	8	13	4.3	--	--	--	--	--
<i>M. pacificus</i>	--	--	--	--	--	--	--	--	--	--
Flathead sole	--	--	--	--	--	--	--	--	--	--
<i>H. elassodon</i>	--	--	--	--	--	--	--	--	--	--
Rex sole	--	--	--	--	--	--	--	--	--	--
<i>G. zachirus</i>	--	--	--	--	--	--	--	--	--	--
Pacific sanddab	--	--	--	--	--	--	--	--	--	--
<i>C. sordidus</i>	--	--	--	--	--	--	--	--	--	--
Speckled sanddab	--	--	--	--	--	--	--	--	--	--
<i>C. stigmaeus</i>	--	--	--	--	--	--	--	--	--	--
Arrowtooth flounder	--	--	--	--	--	--	--	--	--	--
<i>A. stomias</i>	--	--	--	--	--	--	--	--	--	--
Starry flounder	--	--	--	--	--	--	--	--	--	--
<i>P. stellatus</i>	--	--	--	--	--	--	--	--	--	--
Sand sole	--	--	--	--	--	--	--	--	--	--
<i>P. melanostictus</i>	--	--	--	--	--	--	--	--	--	--
Petrale sole	--	--	--	--	--	--	--	--	--	--
<i>E. jordani</i>	--	--	--	--	--	--	--	--	--	--
Quillback rockfish	--	--	--	--	--	--	--	--	--	--
<i>S. maliger</i>	--	--	--	--	--	--	--	--	--	--

(Sheet 1 of 42)



Table A1 (Continued)

Species	February 11, 1976				February 13, 1976			
	East Reference				West Reference			
	Trawl #1	Trawl #2	Trawl #3	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Avg/ Trawl
<b>VERTEBRATES</b>								
Redstripe rockfish	--	--	--	--	--	--	--	--
<i>S. proxiger</i>	--	--	--	--	--	--	--	--
Brown rockfish	--	--	--	--	--	--	--	--
<i>S. auriculatus</i>	2	1	--	1.0	--	--	--	--
Copper rockfish	--	--	--	--	--	--	--	--
<i>S. caurinus</i>	--	--	--	--	--	--	4	1.7
Pacific tomcod	--	--	--	--	--	--	--	--
<i>M. proximus</i>	--	--	--	--	--	--	--	--
Pacific cod	7	3	--	3.3	--	--	--	--
<i>G. macrocephalus</i>	1	3	--	1.3	--	3	3	3.7
<i>M. productus</i>	90	21	8	39.7	1	2	1	102.9
Walleye pollock	--	--	--	--	--	--	--	--
<i>T. chalcogrammus</i>	--	--	--	--	--	--	--	--
Shiner perch	--	--	--	--	--	--	1	0.7
<i>C. aggregata</i>	--	--	--	--	--	--	--	--
Pile perch	--	--	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--	--	--
Whitespotted greenling	--	--	--	--	--	--	--	--
<i>H. stelleri</i>	--	--	--	--	--	--	--	--
Pacific staghorn sculpin	--	--	--	--	--	--	2	0.7
<i>L. armatus</i>	--	--	--	--	--	--	--	--
Slim sculpin	--	--	--	--	--	--	--	--
<i>R. asprellus</i>	--	--	--	--	--	--	--	--
Spinyhead sculpin	--	--	--	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	February 11, 1976				February 13, 1976				
	East Reference		Disposal Site		West Reference		Avg/ Trawl		
	Trawl #1	Trawl #2	Trawl #3	Total	Trawl #1	Trawl #2		Trawl #3	Total
VERTEBRATES									
Roughback sculpin	--	--	--	--	--	--	1	1	0.3
<i>C. pugetensis</i>	--	--	--	--	--	--	--	--	--
Soft sculpin	--	--	--	--	--	--	--	--	--
<i>G. sigalutes</i>	--	--	--	--	--	--	--	--	--
Showy snailfish	--	--	1	1	--	--	--	--	--
<i>L. pulchellus</i>	--	--	--	--	--	--	--	--	--
(Pacific) snake prickleback	--	--	--	--	--	--	--	--	--
<i>L. saggita</i>	--	--	--	--	--	--	--	--	--
Bluebarred prickleback	--	--	--	--	--	--	--	--	--
<i>P. evides</i>	--	--	--	--	--	--	--	--	--
Northern ronquil	--	--	--	--	--	--	--	--	--
<i>R. jordani</i>	--	--	--	--	--	--	--	--	--
Sturgeon poacher	--	--	--	--	--	1	--	1	0.3
<i>A. acipenserinus</i>	--	--	--	--	--	--	3	1	1.3
Blacktip poacher	--	--	--	--	--	--	--	--	--
<i>X. latifrons</i>	--	--	--	--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--	--	--	--	--
<i>G. trispinosa</i>	--	--	--	--	--	--	--	--	--
Bluespotted poacher	--	--	--	--	--	--	--	--	--
<i>X. triacanthus</i>	--	--	--	--	--	--	--	3	1.0
Spinycheek starsnout poacher	--	--	--	--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	February 11, 1976						February 13, 1976					
	East Reference			Disposal Site			West Reference			West Reference		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>VERTEBRATES</u>												
Plainfin midshipman	4	6	5	15	5.0		22	1	2	25	8.3	
<i>P. notatus</i>	--	--	--	--	--		--	--	--	--	--	
Blackbelly eelpout	--	--	--	--	--		--	--	--	--	--	
<i>L. pacifica</i>	--	--	--	--	--		--	--	--	--	--	
Red brotula	--	--	--	--	--		--	--	--	--	--	
<i>B. marginata</i>	2	1	--	3	1.0		1	4	3	8	2.7	
Ratfish	--	--	--	--	--		--	--	--	--	--	
<i>H. colliei</i>	--	--	--	--	--		--	--	--	--	--	
Rockfish	--	--	--	--	--		--	--	--	--	--	
<i>Sebastes</i> sp.	--	--	--	--	--		--	--	--	--	--	
Longfin smelt	--	--	--	--	--		--	--	--	--	--	
<i>S. thaleichthys</i>	--	--	--	--	--		--	--	--	--	--	
Spiny dogfish	--	--	--	--	--		--	--	--	--	--	
<i>S. acanthias</i>	--	--	--	--	--		--	--	--	--	--	
Tube-snout	--	--	--	--	--		--	--	--	--	--	
<i>A. flavidus</i>	--	--	--	--	--		--	--	--	--	--	

Table A1 (Continued)

Species	February 11, 1976						February 13, 1976								
	East Reference					Avg/ Trawl	Disposal Site			Avg/ Trawl	West Reference			Avg/ Trawl	
	Trawl #1	Trawl #2	Trawl #3	Total	Trawl #1		Trawl #2	Trawl #3	Total		Trawl #1	Trawl #2	Trawl #3		Total
<u>INVERTEBRATES</u>															
Dungeness crab	--	--	--	--	--	--	--	--	--	--	--	--	1	1	0.3
<i>C. magister</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Baird crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. bairdi</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Red crab	--	1	--	1	0.3	--	--	--	--	--	--	--	--	--	--
<i>C. productus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kelp crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. producta</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hermit crab	--	--	--	--	--	--	--	--	--	6	--	--	1	7	2.3
<i>Pagurus</i> sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hybrid tanner crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Decorator crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>O. gracilis</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pink shrimp	703	353	9	1065	355.0	1	102	64	167	274	178	205	657	219.0	
<i>P. borealis</i> & <i>P. jordani</i>	5	3	--	8	2.7	--	--	--	--	12	1	1	14	4.7	
Spot shrimp	141	179	19	339	113.0	5	20	56	81	48	71	--	119	39.7	
<i>P. platyceros</i>	19	14	8	41	13.7	--	4	--	4	--	10	6	16	5.3	
Striped shrimp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>P. danae</i> & <i>P. dispar</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Shrimp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>Crango</i> sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Sea cucumber	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>P. californicus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Starfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>Asteriodea</i> - class	--	--	--	--	--	--	--	1	1	5	3	5	13	4.3	

Table A1 (Continued)

Species	February 11, 1976						February 13, 1976					
	East Reference			Disposal Site			West Reference			West Reference		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>INVERTEBRATES</u>												
Vermillion starfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. aequalis</i>	--	--	--	--	--	--	--	--	--	--	--	--
Sea slugs	--	--	--	--	--	--	--	--	--	--	--	--
Nudibranchs	7	1	--	8	2.7	--	--	--	--	--	--	--
Sea anemone	--	--	--	--	--	--	--	--	--	--	--	--
Squids	--	1	--	1	0.3	--	--	--	--	--	--	--
Octopi	--	--	--	--	--	--	--	--	--	--	--	--
Chiton	--	--	--	--	--	--	--	--	--	--	--	--
<i>Amphineura</i> - class	--	--	--	--	--	--	--	--	--	--	--	--
Spiny shrimp	--	--	--	--	--	--	--	--	--	--	--	--
Broken-back shrimp	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. lamellicornis</i>	--	--	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	March 2, 1976						March 3, 1976									
	East Reference			Disposal Site			West Reference									
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<b>VERTEBRATES</b>																
English sole	28	124	30	182	60.7	47	110	261	418	139.3	59	65	53	177	59.0	
<i>P. vetulus</i>	1	22	4	27	9.0	3	1	--	4	1.3	30	30	31	91	30.3	
Rock sole	--	9	--	9	3.0	5	5	5	15	5.0	2	1	3	6	2.0	
<i>L. bilineata</i>	--	189	5	194	64.7	20	18	13	51	17.0	16	18	14	48	16.0	
Slender sole	--	267	13	281	93.7	5	8	4	17	5.7	2	--	3	5	1.7	
<i>L. exilis</i>	1	109	1	121	40.3	5	2	2	9	3.0	2	1	4	7	2.3	
Dover sole	--	--	--	--	--	--	--	--	--	--	--	--	2	2	0.7	
<i>M. pacificus</i>	--	2	--	2	0.7	--	--	--	--	--	--	--	--	1	0.3	
Flathead sole	--	--	--	--	--	--	1	--	1	0.3	--	--	--	--	--	
<i>H. elassodon</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Rex sole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>G. zachirus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Pacific sanddab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>C. sordidus</i>	--	2	--	2	0.7	--	--	--	--	--	--	--	--	1	1	0.3
Speckled sanddab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>C. stigmaeus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Arrowtooth flounder	--	--	--	--	--	--	1	--	1	0.3	--	--	--	--	--	
<i>A. stomias</i>	--	2	--	2	0.7	3	--	--	3	1.0	--	--	--	--	--	
Starry flounder	--	1	--	1	0.3	--	--	--	--	--	--	--	--	--	--	
<i>P. stellatus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Sand sole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>P. melanostictus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Petrale sole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>E. jordani</i>	--	1	--	1	0.3	2	--	--	2	0.7	4	6	3	13	4.3	
Quillback rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>S. maliger</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

(Sheet 7 of 42)

Table A1 (Continued)

Species	March 2, 1976				March 3, 1976			
	East Reference				West Reference			
	Trawl #1	Trawl #2	Trawl #3	Avg/ Total Trawl	Trawl #1	Trawl #2	Trawl #3	Avg/ Total Trawl
<b>VERTEBRATES</b>								
Redstripe rockfish	--	4	--	4 1.3	6	--	1	7 2.3
<i>S. proziger</i>	--	1	--	1 0.3	--	--	--	--
Brown rockfish	--	--	--	--	--	--	1	1 0.3
<i>S. auriculatus</i>	--	--	--	--	--	--	1	1 0.3
Copper rockfish	25	9	1	35 11.7	19	9	2	30 10.0
<i>S. caurinus</i>	--	--	--	--	--	--	--	--
Pacific tomcod	--	--	--	--	--	--	--	--
<i>M. proximus</i>	--	3	--	3 1.0	--	--	1	1 0.3
Pacific cod	--	1	--	1 0.3	1	--	--	1 0.3
<i>G. macrocephalus</i>	5	1015	118	1138 379.3	260	49	4	313 104.3
Pacific hake	1	3	1	5 1.7	1	1	--	2 0.7
<i>K. productus</i>	--	--	--	--	--	--	--	--
Walleye pollock	--	--	--	--	--	--	--	--
<i>T. chalcogrammus</i>	--	16	1	17 5.7	8	--	--	8 2.7
Shiner perch	--	2	--	2 0.7	--	--	--	--
<i>C. aggregata</i>	--	1	--	1 0.3	--	--	--	--
Pile perch	--	--	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--	--	--
Whitespotted greenling	--	--	--	--	--	--	--	--
<i>H. stelleri</i>	--	--	--	--	--	--	--	--
Pacific staghorn sculpin	--	2	--	2 0.7	--	--	--	--
<i>L. armatus</i>	--	1	--	1 0.3	--	--	--	--
Slim sculpin	--	--	--	--	--	--	--	--
<i>R. asprellus</i>	--	--	--	--	--	--	--	--
Spinyhead sculpin	--	--	--	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	March 2, 1976					March 3, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
VERTEBRATES										
Roughback sculpin	--	1	--	1	0.3	--	--	--	--	--
<i>C. pugetensis</i>	--	--	--	--	--	--	--	--	--	--
Soft sculpin	--	--	--	--	--	--	--	--	--	--
<i>G. sigalutes</i>	--	--	--	--	--	--	--	--	--	--
Showy snailfish	--	--	--	--	--	--	--	--	--	--
<i>L. pulchellus</i>	--	--	--	--	--	--	--	--	--	--
(Pacific) snake prickleback	--	1	--	1	0.3	--	--	--	--	--
<i>L. sagitta</i>	--	--	--	--	--	--	--	--	--	--
Bluebarred prickleback	--	--	--	--	--	--	--	--	--	--
<i>P. evides</i>	--	--	--	--	--	--	--	--	--	--
Northern ronquil	--	--	--	--	--	--	--	--	--	--
<i>R. jordani</i>	--	--	--	--	--	--	--	--	--	--
Sturgeon poacher	--	--	--	--	--	--	--	--	--	--
<i>A. acipenserinus</i>	--	--	--	--	--	--	--	--	--	--
Blacktip poacher	--	--	--	--	--	--	--	--	--	--
<i>X. latifrons</i>	--	--	--	--	--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--	--	--	--	--	--
<i>O. trispinosa</i>	1	--	--	1	0.3	--	--	--	--	--
Bluespotted poacher	--	--	--	--	--	--	--	--	--	--
<i>X. triacanthus</i>	--	1	--	1	0.3	--	--	--	--	--
Spinycheek starsnout poacher	--	--	--	--	--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	March 2, 1976						March 3, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>VERTEBRATES</u>												
Plainfin midshipman	--	32	1	33	11.0		3	6	1	10	3.3	
<i>P. nectatus</i>	--	4	--	4	1.3		--	--	--	--	--	
Blackbelly eelpout	--	--	--	--	--		2	--	--	2	0.7	
<i>L. pacifica</i>	--	--	1	1	0.3		--	--	2	2	0.7	
Red brotula	--	--	--	--	--		1	--	--	1	0.3	
<i>B. marginata</i>	--	--	--	--	--		1	--	--	1	0.3	
Ratfish	--	3	1	4	1.3		--	--	--	--	--	
<i>H. coliei</i>	--	--	--	--	--		--	--	--	--	--	
Rockfish	--	--	--	--	--		--	--	--	--	--	
sebastes sp.	--	--	--	--	--		--	--	--	--	--	
Longfin smelt	--	--	--	--	--		--	--	--	--	--	
<i>S. thaleichthys</i>	--	--	1	1	0.3		--	--	--	--	--	
Spiny dogfish	--	--	--	--	--		--	--	--	--	--	
<i>S. acanthias</i>	--	--	--	--	--		--	--	--	--	--	
Tube-snout	--	--	--	--	--		--	--	--	--	--	
<i>A. flavidus</i>	--	--	--	--	--		--	--	--	--	--	

Table A1 (Continued)

Species	March 2, 1976					March 3, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>INVERTEBRATES</u>										
Dungeness crab	--	--	--	--	--	1	--	--	1	0.3
<i>C. magister</i>	--	--	--	--	--	--	--	--	--	--
Baird crab	--	--	--	--	--	--	--	--	--	--
<i>C. bairdi</i>	--	--	--	--	--	1	--	--	1	0.3
Red crab	--	--	--	--	--	1	--	--	1	0.3
<i>C. productus</i>	--	--	--	--	--	1	--	--	1	0.3
Kelp crab	--	--	--	--	--	--	--	--	--	--
<i>P. producta</i>	--	--	--	--	--	--	--	--	--	--
Hermit crab	--	--	--	--	--	--	--	--	--	--
<i>Pagurus</i> sp.	--	--	--	--	--	1	--	--	1	0.3
Hybrid tanner crab	--	--	--	--	--	--	--	--	--	--
Decorator crab	--	--	--	--	--	--	--	--	--	--
<i>O. gracilis</i>	53	358	23	434	144.7	33	124	97	254	84.7
Pink shrimp	--	--	1	1	0.3	10	12	2	24	8.0
<i>P. borealis</i> & <i>P. jordanii</i>	--	68	2	70	23.3	21	33	23	77	25.7
<i>P. platyceros</i>	--	126	--	126	42.0	--	2	--	2	0.7
Striped shrimp	--	--	--	--	--	--	--	--	--	--
<i>P. danae</i> & <i>P. dispar</i>	--	--	--	--	--	--	--	--	--	--
Shrimp	--	--	--	--	--	--	--	--	--	--
<i>Crago</i> sp.	--	--	--	--	--	--	--	--	--	--
Sea cucumber	--	--	--	--	--	--	--	--	--	--
<i>P. californicus</i>	--	--	--	--	--	--	--	--	--	--
Starfish	--	--	--	--	--	--	--	--	--	--
<i>Asteriodes</i> - class	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	March 2, 1976						March 3, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>INVERTEBRATES</u>												
Vermillion starfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. aequalis</i>	--	--	--	--	--	--	--	--	--	--	--	--
Sea slugs	--	--	--	--	--	--	--	--	--	--	--	--
Nudibranchs	--	1	--	1	0.3	--	--	3	--	3	1.0	--
Sea anemone	--	--	--	--	--	--	--	--	--	--	--	--
Squids	--	--	--	--	--	--	--	--	--	--	--	--
Octopi	--	1	--	1	0.3	--	--	--	--	--	--	--
Chiton	--	--	--	--	--	--	--	--	--	--	--	--
Amphineura - class	--	--	--	--	--	--	--	--	--	--	--	--
Spiny shrimp	--	1	--	1	0.3	--	--	--	--	2	0.7	--
Broken-back shrimp	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. lamellicornis</i>	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	March 22, 1976						March 23, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>VERTEBRATES</u>												
English sole	2	1	--	3	1.0		80	85	5	170	56.7	
<i>P. vetulus</i>												
Rock sole	2	--	--	2	0.7		--	--	--	--	--	
<i>L. bilineata</i>												
Slender sole	2	2	--	4	1.3		8	31	--	39	13.0	
<i>L. exilis</i>												
Dover sole	31	30	30	91	30.3		2	6	15	23	7.7	
<i>M. pacificus</i>												
Flathead sole	65	50	57	172	57.3		--	--	33	33	11.0	
<i>H. elassodon</i>												
Rex sole	26	9	17	52	17.3		--	--	9	9	3.0	
<i>G. zachirus</i>												
Pacific sanddab	--	--	--	--	--		--	--	--	--	--	
<i>C. sordidus</i>												
Speckled sanddab	--	--	--	--	--		--	--	--	--	--	
<i>C. stigmaeus</i>												
Arrowtooth flounder	--	--	--	--	--		--	--	--	--	--	
<i>A. stomias</i>												
Starry flounder	2	--	--	2	0.7		--	--	--	--	--	
<i>P. stellatus</i>												
Sand sole	--	--	--	--	--		--	--	--	--	--	
<i>P. melanostictus</i>												
Petrale sole	4	--	--	4	1.3		--	--	--	--	--	
<i>E. jordani</i>												
Quillback rockfish	--	1	--	1	0.3		1	1	--	2	0.7	
<i>S. maliger</i>												

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Table A1 (Continued)

Species	March 22, 1976						March 23, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>VERTEBRATES</u>												
Redstripe rockfish	--	--	--	--	--	6	--	--	--	--	1	0.3
<i>S. proxiger</i>	--	--	--	--	--	--	--	--	--	--	--	--
Brown rockfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. auriculatus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Copper rockfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. caurinus</i>	4	2	--	6	2.0	1	1	1	1	3	3.0	2.7
Pacific tomcod	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. proximus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Pacific cod	--	--	--	--	--	--	--	--	--	--	--	--
<i>G. macrocephalus</i>	--	10	5	15	5.0	4	1	--	--	5	1.7	1.3
Pacific hake	--	--	--	--	--	1	--	--	--	1	0.3	1.3
<i>M. productus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Walleye pollock	53	118	85	236	85.3	1	6	183	190	63.3	59.0	
<i>T. chalcogrammus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Shiner perch	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. aggregata</i>	--	--	--	--	--	--	--	--	--	--	--	--
Pile perch	--	--	--	--	--	--	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--	--	--	--	--	--	--
Whitespotted greenling	7	4	5	16	5.3	--	--	5	5	1.7	0.7	
<i>H. stelleri</i>	--	--	--	--	--	--	--	--	--	--	--	--
Pacific staghorn sculpin	--	--	--	--	--	--	--	--	--	--	--	--
<i>L. armatus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Slim sculpin	--	--	--	--	--	--	--	--	--	--	--	--
<i>R. asprellus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Spinyhead sculpin	--	--	--	--	--	--	--	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--	--	--	--	--	--	--

(Sheet 14 of 42)

Table A1 (Continued)

Species	March 22, 1976						March 23, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<b>VERTEBRATES</b>												
Roughback sculpin	--	--	--	--	--		--	--	--	--	--	--
<i>C. pugetensis</i>	--	--	--	--	--		--	--	--	--	--	--
Soft sculpin	--	--	--	--	--		--	--	--	--	--	--
<i>G. sigalutes</i>	--	--	--	--	--		--	--	--	--	--	--
Showy snailfish	--	--	--	--	--		--	--	--	--	--	--
<i>L. pulchellus</i>	--	--	--	--	--		--	--	--	--	--	--
(Pacific) snake	--	--	--	--	--		--	--	--	--	--	--
prickleback	--	--	--	--	--		--	--	--	--	--	--
<i>L. saggita</i>	--	--	--	--	--		--	--	--	--	--	--
Bluebarred	--	--	--	--	--		--	--	--	--	--	--
prickleback	--	--	--	--	--		--	--	--	--	--	--
<i>P. evide</i>	--	--	--	--	--		--	--	--	--	--	--
Northern ronquil	--	--	--	--	--		--	--	--	--	--	--
<i>R. jordan</i>	--	--	--	--	--		--	--	--	--	--	--
Sturgeon poacher	--	--	--	--	--		--	--	--	--	--	--
<i>A. acipenserinus</i>	--	--	--	--	--		--	--	--	--	--	--
Blacktip poacher	--	--	--	--	--		--	--	--	--	--	--
<i>X. latifrons</i>	--	--	--	--	--		--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--		--	--	--	--	--	--
<i>O. trispinosa</i>	--	--	--	--	--		--	--	--	--	--	--
Bluespotted	--	--	--	--	--		--	--	--	--	--	--
poacher	--	--	--	--	--		--	--	--	--	--	--
<i>X. triacanthus</i>	--	--	--	--	--		--	--	--	--	--	--
Spinycheek starsnout	--	--	--	--	--		--	--	--	--	--	--
poacher	--	--	--	--	--		--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--		--	--	--	--	--	--

Table A1 (Continued)

Species	March 22, 1976										March 23, 1976				
	East Reference					Disposal Site					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>VERTEBRATES</u>															
Plainfin midshipman	2	3	--	5	1.7	1	2	--	3	1.0	11	2	14	27	9.0
<i>P. notatus</i>	--	--	--	--	--	1	1	--	2	0.7	1	1	2	4	1.3
Blackbelly eelpout	--	--	--	--	--	1	1	--	2	0.7	--	--	--	--	--
<i>L. pacifica</i>	--	--	--	--	--	1	1	--	2	0.7	--	--	--	--	--
Red protula	--	--	--	--	--	3	5	--	8	2.7	--	--	--	--	--
<i>B. marginata</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ratfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>H. colliei</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>sebastes</i> sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Longfin smelt	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. thaleichthys</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spiny dogfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. acanthias</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tube-snout	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>A. f.avidus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	March 22, 1976						March 23, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>INVERTEBRATES</u>												
Dungeness crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. magister</i>												
Baird crab	1	--	--	1	0.3	--	--	--	--	--	--	--
<i>C. bairdi</i>												
Red crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. productus</i>												
Kelp crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. producta</i>												
Hermit crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>Pagurus</i> sp.												
Hybrid tanner crab	--	--	--	--	--	--	--	--	--	--	--	--
Decorator crab												
<i>O. gracilis</i>												
Pink shrimp	282	98	63	443	147.7	180	370	105	655	218.3	221	168
<i>P. borealis</i> & <i>P. jordani</i>												
Spot shrimp	6	2	4	12	4.0	9	1	1	11	3.7	12	21
<i>P. platyceros</i>												
Striped shrimp	71	3	52	126	42.0	8	66	14	88	29.3	11	26
<i>P. danae</i> & <i>P. dispar</i>												
Shrimp	4	5	4	13	4.3	3	12	10	25	8.3	2	5
<i>Crango</i> sp.												
Sea cucumber	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. californicus</i>												
Starfish	--	--	--	--	--	--	--	--	--	--	--	--
Asteriodes - class												

Table A1 (Continued)

Species	March 22, 1976						March 23, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>INVERTEBRATES</u>												
Vermillion starfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. aequalis</i>	--	--	--	--	--	--	--	--	--	--	--	--
Sea slugs	--	--	--	--	--	--	--	--	--	--	--	--
Nudibranchs	--	--	--	--	--	--	--	--	--	--	--	--
Sea anemone	--	--	--	--	--	--	--	--	--	--	--	--
Squids	1	--	--	1	0.5	--	--	--	--	1	0.3	--
Octopi	--	--	--	--	--	--	--	--	--	--	--	--
Chiton	--	--	--	--	--	--	--	--	--	--	--	--
<i>Amphineura</i> - class	--	--	--	--	--	--	--	--	--	--	--	--
Spiny shrimp	--	--	--	--	--	--	--	--	--	--	--	--
Broken-back shrimp	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. lamellicornis</i>	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	East Reference					Disposal Site					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<b>VERTEBRATES</b>															
English sole	1	4	--	5	1.7	1	--	--	1	0.3	42	6	29	77	25.7
<i>P. vetulus</i>	--	2	7	9	3.0	--	--	--	--	--	12	15	22	49	16.3
Rock Sole	1	1	--	2	0.7	10	6	14	30	10.0	3	--	3	6	2.0
<i>L. bilineata</i>	29	30	21	80	26.7	1	2	1	4	1.3	12	--	10	22	7.3
Slender sole	48	75	58	181	60.3	--	--	--	--	--	--	--	1	1	0.3
<i>L. exilis</i>	28	21	38	87	29.0	--	--	--	--	--	4	--	9	13	4.3
Dover sole	--	--	--	--	--	--	--	--	--	--	1	--	--	1	0.3
<i>M. pacificus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Flathead sole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>H. elassodon</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rex sole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>G. zachirus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pacific sanddab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. sordidus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Speckled sanddab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. stigmaeus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arrowtooth flounder	--	--	--	--	--	--	--	2	2	0.7	--	--	--	--	--
<i>A. stomias</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Starry flounder	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. stellatus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sand sole	3	--	--	3	1.0	--	--	--	--	--	--	--	--	--	--
<i>P. melanostictus</i>	1	1	--	2	0.7	--	1	--	1	0.3	3	--	2	5	1.7
Petrale sole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>B. jordani</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Quillback rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. maliger</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	East Reference						April 12, 1976						West Reference					
	Trawl			Total			Disposal Site			Trawl			Trawl			Trawl		
	#1	#2	#3			Avg/ Trawl	#1	#2	#3			Avg/ Trawl	#1	#2	#3			Avg/ Trawl
<u>VERTEBRATES</u>																		
Redstripe rockfish	3	--	--	3	1.0		2	--	13	15	5.0		3	--	4	7	2.3	
<i>S. proriger</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Brown rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. auriculatus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Copper rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. caurinus</i>	--	1	--	1	0.3		--	--	--	--	--	--	1	1	10	12	4.0	
Pacific tomcod	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. proximus</i>	--	--	--	--	--	--	--	1	--	1	0.3		--	--	2	2	0.7	
<i>G. macrocephalus</i>	--	--	--	--	--	--	3	--	--	3	1.0		--	--	--	--	--	--
Pacific hake	--	--	--	--	--	--	1	--	2	3	1.0		--	--	4	4	1.3	
<i>M. productus</i>	--	5	2	8	2.7		--	--	--	--	--	--	3	33	81	117	39.0	
Walleye pollock	1	--	--	--	--	--	--	--	--	--	--	--	3	--	8	11	3.7	
<i>T. chalcogrammus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shiner perch	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. aggregata</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pile perch	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Whitespotted greenling	7	7	6	20	6.7		--	--	--	--	--	--	1	--	2	3	1.0	
<i>H. stelleri</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pacific staghorn sculpin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>L. armatus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Slim sculpin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>R. asprellus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spinyhead sculpin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	April 12, 1976					
	East Reference			Disposal Site		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
VERTEBRATES						
Roughback sculpin	--	--	--	--	--	4 1 4 9 3.0
<i>C. pugetensis</i>	--	--	--	--	--	--
Soft sculpin	--	--	--	--	1 0.3	--
<i>G. sigalutes</i>	--	--	--	--	--	--
Showy snailfish	--	--	--	--	--	--
<i>L. pulchellus</i>	--	--	--	--	--	--
(Pacific) snake prickleback	--	--	--	--	--	--
<i>L. sagyita</i>	--	--	--	--	--	--
Blue barred prickleback	--	--	--	--	--	--
<i>P. evides</i>	--	--	--	--	--	--
Northern ronquill	--	--	--	--	1 0.3	2 0.7
<i>R. jordani</i>	--	--	--	--	--	--
Sturgeon poacher	--	--	--	--	--	--
<i>A. acipenserinus</i>	--	--	--	--	--	--
Blacktip poacher	--	--	--	--	1 1.0	1 0.3
<i>X. latifrons</i>	--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--	--
<i>O. trispinosa</i>	--	--	--	--	--	--
Bluespotted poacher	--	--	--	--	--	--
<i>X. triacanthus</i>	--	--	--	--	--	--
Spinycheek starsnout poacher	--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--	--



Table A1 (Continued)

Species	April 12, 1976									
	East Reference					Disposal Site				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<b>VERTEBRATES</b>										
Plainfin midshipman	16	27	30	73	24.3	--	--	--	--	--
<i>P. notatus</i>	--	--	--	--	--	--	--	--	--	--
Blackbelly eelpout	--	--	--	--	--	--	--	--	--	--
<i>L. pacifica</i>	--	--	--	--	--	--	2	2	4	1.3
Red protula	--	--	--	--	--	1	--	2	3	1.0
<i>B. marginata</i>	--	--	--	--	--	--	--	--	--	--
Ratfish	--	--	--	--	--	--	--	--	--	--
<i>H. colliei</i>	--	--	--	--	--	--	--	--	--	--
Rockfish	--	--	--	--	--	--	--	--	--	--
<i>Sebastes</i> sp.	--	--	--	--	--	--	--	--	--	--
Longfin smelt	--	--	--	--	--	--	--	--	--	--
<i>S. thaleichthys</i>	--	--	--	--	--	--	--	--	--	--
Spiny dogfish	--	--	--	--	--	--	--	--	--	--
<i>S. acanthias</i>	--	--	--	--	--	--	--	--	--	--
Tube-snout	--	--	--	--	--	--	--	--	--	--
<i>A. flavidus</i>	--	--	--	--	--	--	--	1	1	0.3

Table A1 (Continued)

Species	April 12, 1976								
	East Reference			Disposal Site			West Reference		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total
<u>INVERTEBRATES</u>									
Dungeness crab	--	--	--	--	--	--	--	--	--
<i>C. magister</i>	--	--	2	2	0.7	--	--	--	1
Baird crab	--	--	--	--	--	--	--	--	--
<i>C. bairdi</i>	--	--	--	--	--	--	--	--	--
Red crab	--	--	--	--	--	--	--	--	--
<i>C. productus</i>	--	--	--	--	--	13	13	4.3	--
Kelp crab	--	--	--	--	--	--	--	--	--
<i>P. producta</i>	--	--	--	--	--	--	--	--	1
Hermit crab	--	--	--	--	--	--	--	--	--
<i>Pagurus</i> sp.	--	1	--	1	0.3	--	--	--	--
Hybrid Tanner crab	--	--	--	--	--	--	--	--	--
Decorator crab	--	--	--	--	--	--	--	--	--
<i>O. gracilis</i>	76	118	130	324	108.0	418	169	291	878
Pink shrimp	10	--	6	16	5.3	2	1	4	7
<i>P. borealis</i> & <i>P. jordani</i>	91	58	113	262	87.3	10	25	10	45
Spot shrimp	5	5	12	22	7.3	--	4	5	9
<i>P. platyceros</i>	--	--	--	--	--	--	--	--	--
Striped shrimp	--	--	--	--	--	--	--	--	--
<i>P. danae</i> & <i>P. dispar</i>	--	--	--	--	--	--	--	--	--
Shrimp	1	--	1	2	0.7	--	--	--	--
<i>Crago</i> sp.	--	--	--	--	--	--	--	--	--
Sea cucumber	--	--	--	--	--	--	--	--	--
<i>P. californicus</i>	--	--	--	--	--	--	--	--	--
Starfish	--	--	--	--	--	--	--	--	--
Asteriidea - class	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	April 12, 1976									
	East Reference					Disposal Site				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>INVERTEBRATES</u>										
Vermillion starfish	--	--	--	--	--	--	--	--	--	--
<i>M. aequalis</i>	--	--	--	--	--	--	--	--	--	--
Sea slugs	--	--	--	--	--	--	--	--	--	--
Nudibranchs	--	3	2	5	1.7	--	3	56	59	19.7
Sea anemone	--	--	--	--	--	--	--	--	--	--
Squids	--	1	--	1	0.3	1	--	--	1	0.3
Octopi	--	--	--	--	--	--	--	--	--	--
Chiton	--	--	--	--	--	--	--	--	--	--
Amphineura - class	--	--	--	--	--	--	--	--	--	--
Spiny shrimp	--	--	--	--	--	--	--	--	--	--
Broken-back shrimp	--	--	--	--	--	--	--	--	--	--
<i>S. lamellicornis</i>	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

[illegible]

Table A1 (Continued)

June 14, 1976

Species	East Reference				Disposal Site				West Reference						
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
VERTEBRATES															
Redstripe rockfish	--	--	--	--	--	--	--	--	--	--	--	--	1	1	0.3
<i>S. proriger</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Brown rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. auriculatus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Copper rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. caurinus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pacific tomcod	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. proximus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pacific cod	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>G. macrocephalus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pacific hake	12	42	--	54	18.0	1	1	1	3	1.0	--	--	--	--	--
<i>M. productus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Walleye pollock	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>T. chalcogrammus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shiner perch	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. aggregata</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pile perch	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Whitespotted greenling	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>H. stelleri</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pacific staghorn sculpin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>L. armatus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Slim sculpin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>R. asprellus</i>	--	--	--	--	--	--	--	--	--	--	--	--	1	1	0.3
Spinyhead sculpin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	June 14, 1976									
	East Reference					Disposal Site				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>VERTEBRATES</u>										
Roughback sculpin	--	--	--	--	--	--	--	--	--	--
<i>C. pugetensis</i>	--	--	--	--	--	--	--	--	--	--
Soft sculpin	--	--	--	--	--	--	--	--	--	--
<i>G. sigalutes</i>	--	--	--	--	--	--	--	--	--	--
Showy snailfish	--	--	--	--	--	--	--	--	--	--
<i>L. pulchellus</i>	--	--	--	--	--	--	--	--	--	--
(Pacific) snake	--	--	--	--	--	--	--	--	--	--
prickleback	--	--	--	--	--	--	--	1	1	0.3
<i>L. saggita</i>	--	--	--	--	--	--	--	--	--	--
Bluebarred	--	--	--	--	--	--	--	--	--	--
prickleback	--	--	--	--	--	--	--	--	--	--
<i>P. evides</i>	--	--	--	--	--	--	--	--	--	--
Northern ronquil	--	--	--	--	--	--	1	--	1	0.3
<i>R. jordani</i>	--	--	--	--	--	--	--	--	--	--
Sturgeon poacher	--	--	--	--	--	--	--	--	--	--
<i>A. acipenserinus</i>	--	--	--	--	--	--	--	--	--	--
Blacktip poacher	--	--	--	--	--	--	1	5	6	2.0
<i>X. latifrons</i>	--	--	--	--	--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--	--	--	--	--	--
<i>O. trispinosa</i>	--	--	--	--	--	--	--	--	--	--
Bluespotted	--	--	--	--	--	--	--	--	--	--
poacher	--	--	--	--	--	--	--	--	--	--
<i>X. triacanthus</i>	--	--	--	--	--	--	--	--	--	--
Spinycheek starsnout	--	--	--	--	--	--	--	--	--	--
poacher	--	--	--	--	--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--	--	--	--	--	--

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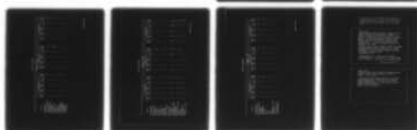
NATIONAL MARINE FISHERIES SERVICE MUKILTEO WA NORTHW--ETC F/G 6/3  
AQUATIC DISPOSAL FIELD INVESTIGATIONS, DUWAMISH WATERWAY DISPOS--ETC(U)  
MAY 78 J R HUGHES, W E AMES, D A MISITANO WESRF-7T-22

WES-TR-D-77-24-APP-A

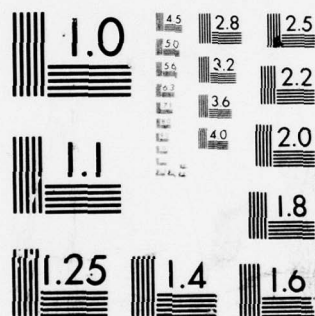
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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

Table A1 (Continued)

Species	East Reference					Disposal Site					West Reference				
	Trawl		Trawl #3	Total	Avg/ Trawl	Trawl		Trawl #3	Total	Avg/ Trawl	Trawl		Trawl #3	Total	Avg/ Trawl
	#1	#2				#1	#2				#1	#2			
VERTEBRATES															
Plainfin midshipman	11	24	9	44	14.7	--	--	--	--	--	--	--	--	--	--
<i>P. notatus</i>															
Blackbelly eelpout	3	--	--	3	1.0	--	--	1	1	0.3	1	1	--	2	0.7
<i>L. pacifica</i>															
Red brotula	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>B. marginata</i>															
Ratfish	--	--	--	--	--	1	2	1	4	1.3	5	5	--	10	3.3
<i>H. colliei</i>															
Rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>sebastes</i> sp.															
Longfin smelt	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. thaleichthys</i>															
Spiny dogfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. acanthias</i>															
Tube-snout	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>A. flavidus</i>															

Table A1 (Continued)

Species	June 14, 1976									
	East Reference					Disposal Site				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>INVERTEBRATES</u>										
Dungeness crab	--	1	--	1	0.3	--	--	--	--	--
<i>C. magister</i>	--	--	--	--	--	--	--	--	--	--
Baird crab	--	--	--	--	--	--	--	--	--	--
<i>C. bairdi</i>	--	--	--	--	--	--	--	--	--	--
Red crab	--	--	--	--	--	--	--	--	--	--
<i>C. productus</i>	--	--	--	--	--	--	--	--	--	--
Kelp crab	--	--	--	--	--	--	--	--	--	--
<i>P. producta</i>	--	--	1	1	0.3	--	--	--	--	--
Hermit crab	--	--	--	--	--	--	--	--	--	--
<i>Pagurus</i> sp.	--	--	--	--	--	--	--	--	--	--
Hybrid tanner crab	--	--	--	--	--	--	--	--	--	--
Decorator crab	--	--	--	--	--	--	--	--	--	--
<i>O. gracilis</i>	212	221	88	521	173.7	454	1527	1065	3046	1015.3
Pink shrimp	--	--	4	4	1.3	--	--	--	--	--
<i>P. borealis</i> sp. <i>Jordani</i>	--	--	4	4	1.3	--	--	--	--	--
Spot shrimp	47	136	26	209	69.7	14	90	55	159	53.0
Striped shrimp	17	17	2	36	12.0	1	--	4	5	1.7
<i>P. danae</i> & <i>P. dispar</i>	--	--	--	--	--	--	--	--	--	--
Shrimp	--	--	--	--	--	--	--	--	--	--
Crango sp.	--	3	2	5	1.7	--	--	--	--	--
Sea cucumber	--	--	--	--	--	--	--	--	--	--
<i>P. californicus</i>	--	--	--	--	--	--	--	--	--	--
Starfish	--	--	--	--	--	--	--	--	--	--
Asteriidea - class	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	June 14, 1976									
	East Reference			Disposal Site			West Reference			
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>INVERTEBRATES</u>										
Vermillion starfish <i>M. aequalis</i>	2	--	--	2	0.7	--	--	--	--	--
Sea slugs	--	--	--	--	--	--	--	--	--	--
Nudibranchs	1	4	2	7	2.3	--	1	1	2	0.7
Sea anemone	--	--	--	--	--	--	--	1	1	0.3
Squids	--	--	--	--	--	--	1	--	1	0.3
Octopi	--	--	--	--	--	--	--	--	--	--
Chiton	--	--	--	--	--	--	--	--	--	--
Amphineura - class	--	--	--	--	--	--	--	--	1	0.3
Spiny shrimp	--	--	--	--	--	--	--	--	4	1
Broken-back shrimp <i>S. lamellicornis</i>	--	--	--	--	--	--	--	--	--	1
									1	0.3

Table A1 (Continued)

Species	September 14, 1976					September 15, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<b>VERTEBRATES</b>										
English sole	1	1	2	4	1.3	--	--	1	1	0.3
<i>P. vetulus</i>										
Rock sole	2	5	4	11	3.7	--	--	--	--	--
<i>L. bilineata</i>										
Slender sole	3	--	--	3	1.0	6	5	7	18	6.0
<i>L. exilis</i>										
Dover sole	52	29	17	98	32.7	13	12	11	36	12.0
<i>M. pacificus</i>										
Flathead sole	27	39	24	90	30.0	4	7	6	17	5.7
<i>H. elassodon</i>										
Rex sole	15	22	28	65	21.7	2	1	1	4	1.3
<i>G. zachirus</i>										
Pacific sanddab	--	--	--	--	--	--	--	--	--	--
<i>C. sordidus</i>										
Speckled sanddab	--	--	--	--	--	--	--	--	--	--
<i>C. stigmaeus</i>										
Arrowtooth flounder	--	--	--	--	--	--	--	--	--	--
<i>A. stomias</i>										
Starry flounder	--	--	--	--	--	--	--	--	--	--
<i>P. stellatus</i>										
Sand sole	--	1	--	1	0.3	--	--	--	--	--
<i>P. melanostictus</i>										
Petrale sole	--	--	--	--	--	--	--	--	--	--
<i>E. jordani</i>										
Quillback rockfish	1	2	--	3	1.0	1	--	--	1	0.3
<i>S. maliger</i>										

(Sheet 31 of 42)

Table A1 (Continued)

Species	September 14, 1976					September 15, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<b>VERTEBRATES</b>										
Redstripe rockfish	--	--	--	--	--	1	--	1	2	0.7
<i>S. proziger</i>	--	--	--	--	--	--	--	--	--	--
Brown rockfish	--	--	--	--	--	--	--	--	--	--
<i>S. auriculatus</i>	--	--	--	--	--	--	--	--	--	--
Copper rockfish	--	--	--	--	--	--	--	--	--	--
<i>S. caurinus</i>	5	--	1	6	2.0	--	2	1	3	1.0
Pacific tomcod	--	--	--	--	--	--	2	--	2	0.7
<i>M. proximus</i>	--	--	--	--	--	--	--	--	--	--
Pacific cod	--	--	--	--	--	--	--	--	--	--
<i>G. macrocephalus</i>	--	--	--	--	--	--	--	--	--	--
Pacific hake	--	--	--	--	--	--	2	--	2	0.7
<i>M. productus</i>	--	--	--	--	--	--	5	--	5	1.7
Walleye pollock	--	--	--	--	--	--	--	--	--	--
<i>T. chalcogrammus</i>	--	--	--	--	--	--	--	--	--	--
Shiner perch	2	--	--	2	0.7	--	--	--	--	0.3
<i>C. aggregata</i>	--	--	--	--	--	--	--	--	--	--
Pile perch	--	--	--	--	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--	--	--	--	--
Whitespotted greenling	1	--	1	2	0.7	--	--	--	--	--
<i>H. stelleri</i>	--	--	--	--	--	--	--	--	--	--
Pacific staghorn sculpin	--	--	--	--	--	--	--	--	--	--
<i>L. armatus</i>	--	--	--	--	--	--	--	--	--	--
Slim sculpin	--	--	--	--	--	--	--	--	--	--
<i>R. asprellus</i>	--	--	1	1	0.3	--	--	--	--	--
Spinyhead sculpin	1	--	--	1	0.3	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--	--	--	--	--

(Sheet 32 of 42)

Table A1 (Continued)

Species	September 14, 1976					September 15, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>VERTEBRATES</u>										
Roughback sculpin	1	--	2	3	1.0	--	--	--	--	--
<i>C. pugetensis</i>	--	--	--	--	--	--	--	--	--	--
Soft sculpin	--	--	--	--	--	--	--	--	--	--
<i>G. sigalutes</i>	--	--	--	--	--	--	--	--	--	--
Showy snailfish	--	--	--	--	--	--	--	--	--	--
<i>L. pulchellus</i>	--	--	--	--	--	--	--	--	--	--
(Pacific) snake	--	--	--	--	--	--	--	--	--	--
prickleback	--	--	--	--	--	--	--	--	--	--
<i>L. sagitta</i>	--	--	--	--	--	--	--	--	--	--
Bluebarred	--	--	--	--	--	--	--	--	--	--
prickleback	--	--	--	--	--	--	--	--	--	--
<i>P. evides</i>	--	--	--	--	--	--	--	--	--	--
Northern ronquil	--	2	--	2	0.7	--	--	1	1	0.3
<i>R. jordani</i>	--	--	--	--	--	--	--	--	--	--
Sturgeon poacher	--	--	--	--	--	--	--	--	--	--
<i>A. acipenserinus</i>	--	--	--	--	--	2	1	3	6	2.0
Blacktip peacher	--	--	--	--	--	--	--	--	--	--
<i>X. latifrons</i>	--	--	--	--	--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--	--	--	--	--	--
<i>O. crispinosa</i>	--	--	--	--	--	--	--	--	--	--
Bluespotted	--	--	--	--	--	--	--	--	--	--
poacher	--	--	--	--	--	--	--	--	--	--
<i>X. triacanthus</i>	--	--	--	--	--	--	--	--	--	--
Spinycheek starsnout	--	--	--	--	--	--	--	--	--	--
poacher	--	--	--	--	--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	September 14, 1976					September 15, 1976				
	East Reference					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>VERTEBRATES</u>										
Plainfin midshipman	7	7	3	17	5.7	--	--	2	2	0.7
<i>P. notatus</i>	--	--	--	--	--	--	--	--	--	--
Blackbelly eelpout	--	--	--	--	--	--	--	--	--	--
<i>L. pacifica</i>	--	--	--	--	--	--	--	--	--	--
Red brotula	--	--	--	--	--	--	--	--	--	--
<i>B. marginata</i>	--	--	--	--	--	--	--	--	--	--
Ratfish	--	--	--	--	--	--	--	--	--	--
<i>H. colliei</i>	--	--	--	--	--	--	--	--	--	--
Rockfish	--	--	--	--	--	--	--	--	--	--
<i>sebastes</i> sp.	--	--	--	--	--	--	--	--	--	--
Longfin smelt	--	--	--	--	--	--	--	--	--	--
<i>S. thaleichthys</i>	--	--	--	--	--	--	--	--	--	--
Spiny dogfish	--	--	--	--	--	--	--	--	--	--
<i>S. acanthias</i>	--	--	--	--	--	--	--	--	--	--
Tube snout	--	--	--	--	--	--	--	--	--	--
<i>A. flavidus</i>	--	--	--	--	--	--	--	--	--	--



Table A1 (Continued)

Species	September 14, 1976						September 15, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>INVERTEBRATES</u>												
Dungeness crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. magister</i>	--	--	--	--	--	--	--	--	--	--	--	--
Baird crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. bairdi</i>	--	--	--	--	--	--	--	--	--	--	--	--
Red crab	--	--	--	--	--	1	--	--	--	--	0.3	--
<i>C. productus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Kelp crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. producta</i>	--	--	--	--	--	--	--	--	--	--	--	--
Hermit crab	--	--	--	--	--	--	--	--	--	--	--	--
<i>Pagurus</i> sp.	--	--	--	--	--	--	--	--	--	--	--	--
Hybrid tanner crab	--	--	--	--	--	--	--	--	--	--	--	--
Decorator crab	2	--	2	4	1.3	--	--	--	--	--	--	--
<i>O. gracilis</i>	26	50	100	176	58.7	455	375	388	1218	406.0	310	393.7
Pink shrimp	--	--	--	--	--	--	--	--	--	--	1	0.3
<i>P. borealis</i> & <i>P. jordani</i>	--	--	--	--	--	--	--	--	--	--	--	--
Spot shrimp	15	--	--	15	5.0	--	--	--	--	--	--	--
<i>P. platyceros</i>	--	--	--	--	--	--	--	--	--	--	--	--
Striped shrimp	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. danae</i> & <i>P. dispar</i>	--	--	--	--	--	--	--	--	--	--	--	--
Shrimp	--	--	--	--	--	--	--	--	--	--	--	--
Crango sp.	--	--	--	--	--	--	--	--	--	--	--	--
Sea cucumber	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. californicus</i>	--	--	--	--	--	--	--	--	--	--	--	--
Starfish	--	--	--	--	--	--	--	--	--	--	--	--
Asteriodes - class	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	September 14, 1976						September 15, 1976					
	East Reference			Disposal Site			West Reference					
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl		Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>INVERTEBRATES</u>												
Vermillion starfish	--	--	--	--	--	--	--	--	--	--	--	--
<i>M. aequalis</i>	--	--	--	--	--	--	--	--	--	--	--	--
Sea slugs	--	--	--	--	--	--	--	--	--	--	--	--
Nudibranchs	--	--	--	--	--	--	--	--	--	--	--	--
Sea anemone	--	--	--	--	--	--	--	--	--	--	--	--
Squids	1	--	--	1	0.3	--	--	--	1	1	0.3	--
Octopi	--	--	--	--	--	1	--	--	--	--	--	--
Chiton	--	--	--	--	--	--	--	--	--	--	--	--
Amphineura - class	--	--	--	--	--	--	--	--	--	--	--	--
Spiny shrimp	--	--	--	--	--	--	--	--	--	--	--	--
Broken-back shrimp	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. lamellicornis</i>	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	December 7, 1976					
	East Reference			Disposal Site		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
VERTEBRATES						
English sole	--	--	--	--	--	--
<i>P. vetulus</i>	1	2	9	12	4.0	--
Rock sole	1	--	--	1	0.3	--
<i>L. bilineata</i>	1	5	5	11	3.7	--
Slender sole	1	5	9	15	5.0	--
<i>L. exilis</i>	1	5	9	15	5.0	--
Dover sole	1	5	9	15	5.0	--
<i>M. pacificus</i>	1	5	9	15	5.0	--
Flathead sole	1	5	9	15	5.0	--
<i>H. elassodon</i>	1	5	9	15	5.0	--
Rex sole	1	5	9	15	5.0	--
<i>G. zachirus</i>	1	5	9	15	5.0	--
Pacific sanddab	1	5	9	15	5.0	--
<i>C. sordidus</i>	1	5	9	15	5.0	--
Speckled sanddab	1	5	9	15	5.0	--
<i>C. stigmaeus</i>	1	5	9	15	5.0	--
Arrowtooth flounder	1	5	9	15	5.0	--
<i>A. stomias</i>	1	5	9	15	5.0	--
Starry flounder	1	5	9	15	5.0	--
<i>P. stellatus</i>	1	5	9	15	5.0	--
Sand sole	1	5	9	15	5.0	--
<i>P. melanostictus</i>	1	5	9	15	5.0	--
Petrale sole	1	5	9	15	5.0	--
<i>E. jordani</i>	1	5	9	15	5.0	--
Quillback rockfish	1	5	9	15	5.0	--
<i>S. maliger</i>	1	5	9	15	5.0	--

Table A1 (Continued)

Species	December 7, 1976					
	East Reference			Disposal Site		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
<u>VERTEBRATES</u>						
Redstripe rockfish	--	--	--	--	--	--
<i>S. proziger</i>	--	--	--	--	--	--
Brown rockfish	--	--	--	--	--	--
<i>S. auriculatus</i>	--	--	--	--	0.3	5.3
Copper rockfish	1	--	--	1	--	--
<i>S. caurinus</i>	--	--	--	--	--	--
Pacific tomcod	--	--	--	--	--	--
<i>M. proximus</i>	--	--	2	2	0.7	7.7
Pacific cod	--	--	--	--	--	--
<i>G. macrocephalus</i>	--	--	--	--	--	--
Pacific hake	--	--	--	--	--	--
<i>M. productus</i>	--	--	--	--	--	--
Walleye pollock	--	--	--	--	--	--
<i>T. chalcogrammus</i>	--	--	1	1	0.3	2.7
Shiner perch	--	--	--	--	--	--
<i>C. aggregata</i>	--	--	--	--	--	--
Pile perch	--	--	--	--	--	--
<i>R. vacca</i>	--	--	--	--	--	--
Whitespotted greenling	--	--	--	--	--	--
<i>H. stelleri</i>	--	--	3	3	1.0	0.3
Pacific staghorn sculpin	--	--	--	--	--	--
<i>L. armatus</i>	--	--	--	--	--	--
Slim sculpin	--	--	--	--	--	0.3
<i>R. asprellus</i>	--	--	--	--	--	--
Spinyhead sculpin	--	--	--	--	--	--
<i>D. setiger</i>	--	--	--	--	--	--
Yellowtail rockfish	--	--	--	--	--	--
<i>S. flavidus</i>	--	--	--	--	--	--



Table A1 (Continued)

Species	December 7, 1976					
	East Reference			Disposal Site		
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	
VERTEBRATES						
Roughback sculpin	1	1	--	2	0.7	--
<i>C. pugetensis</i>	--	--	--	--	--	--
Soft sculpin	--	--	--	--	--	--
<i>G. sigalutes</i>	--	--	--	--	--	--
Showy snailfish	--	--	--	--	0.3	--
<i>L. pulchellus</i>	--	--	--	--	--	--
(Pacific) snake	--	--	--	--	--	--
prickleback	--	--	--	--	--	--
<i>L. saggita</i>	--	--	--	--	--	--
Bluebarred	--	--	--	--	--	--
prickleback	--	--	--	--	--	--
<i>P. evides</i>	--	--	--	--	--	--
Northern ronquil	--	--	--	--	--	1 2 0.7
<i>R. jordani</i>	--	--	--	--	--	1 4 5 1.7
Sturgeon poacher	--	--	--	--	--	--
<i>A. acipenserinus</i>	--	--	--	--	--	--
Blacktip poacher	--	--	--	--	--	--
<i>X. latifrons</i>	--	--	--	--	--	--
Pygmy poacher	--	--	--	--	--	--
<i>O. trispinosa</i>	--	--	--	--	--	--
Bluespotted	--	--	--	--	--	--
poacher	--	--	--	--	--	--
<i>X. triacanthus</i>	--	--	--	--	--	--
Spinycheek starsnout	--	--	--	--	--	--
poacher	--	--	--	--	--	--
<i>A. infraspinata</i>	--	--	--	--	--	--



Table A1 (Continued)

Species	December 7, 1976														
	East Reference					Disposal Site					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>VERTEBRATES</u>															
Plainfin midshipman	1	1	1	3	1.0	1	1	7	9	3.0	1	6	8	15	5.0
<i>P. notatus</i>	--	--	--	--	--	--	--	--	--	--	3	2	--	5	1.7
Blackbelly eelpout	--	--	--	--	--	2	--	--	2	0.7	--	--	--	--	--
<i>L. pacifica</i>	--	--	--	--	--	1	--	1	2	0.7	--	--	--	--	--
Red brectula	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>B. marginata</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ratfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>H. colliei</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rockfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>sebastes</i> sp.	--	--	1	1	0.3	--	--	--	--	--	--	--	--	--	--
Longfin smelt	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. thaleichthys</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spiny dogfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>S. acanthias</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tube-snout	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>A. flavidus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Continued)

Species	December 7, 1976														
	East Reference					Disposal Site					West Reference				
	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl	Trawl #1	Trawl #2	Trawl #3	Total	Avg/ Trawl
<u>INVERTEBRATES</u>															
Dungeness crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. magister</i>	--	--	--	--	--	1	--	--	1	0.3	--	--	--	--	--
Baird crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. bairdi</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Red crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>C. productus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kelp crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. producta</i>	--	--	--	--	--	1	--	--	1	0.3	--	--	--	--	--
Hermit crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Pagurus</i> sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hybrid tanner crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Decorator crab	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>O. gracilis</i>	2	6	15	23	7.7	22	--	6	28	9.3	105	20	165	290	96.7
Pink shrimp	--	--	--	--	--	2	--	1	3	1.0	1	7	--	8	2.7
<i>P. borealis</i> & <i>P. jordani</i>	--	--	--	--	--	--	--	--	--	--	1	2	1	4	1.3
Spot shrimp	--	--	--	--	--	--	--	--	--	--	2	--	--	2	0.7
<i>P. platyceros</i>	--	--	--	--	--	--	--	--	--	--	1	2	--	3	1.0
Striped shrimp	2	3	3	8	2.7	1	--	--	1	0.3	2	--	--	2	0.7
<i>P. danae</i> & <i>P. dispar</i>	--	--	--	--	--	--	--	--	--	--	1	2	--	3	1.0
Crango sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	1	0.3
Sea cucumber	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>P. californicus</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Starfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Asteriodes</i> - Class	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A1 (Concluded)

[illegible]

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Hughes, John R

Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington; Appendix A: Effects of dredged material disposal on demersal fish and shellfish in Elliott Bay, Seattle, Washington / by John R. Hughes ... [et al.], National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Mukilteo, Wash. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

62, 42 p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-24, Appendix A)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Interagency Agreement No. WESRF 7T-22 (DMRP Work Unit no. 1A10B)

References: p. 61-62.

1. Dredged material.
2. Dredged material disposal.
3. Duwamish Waterway.
4. Elliott Bay.
5. Field investigations.
6. Fishes.
7. Shellfish.
8. Waste disposal sites.

(Continued on next card)

Hughes, John R

Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington; Appendix A: Effects ... 1978. (Card 2)

I. United States. Army. Corps of Engineers. II. United States. National Marine Fisheries Service. Northwest and Alaska Fisheries Center. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-24, Appendix A.  
TA7.W34 no.D-77-24 Appendix A